ADDIS ABABA SCIENCE AND TECHNOLOGY UNIVERSITY

COLLEGE OF BIOLOGICAL AND CHEMICAL ENGINEERING

DEPARTMENT OF ENVIRONMENTAL ENGINEERING

ASSESSMENT OF THE EFFECT OF HUMAN ACTIVITIES ON GROUNDWATER QUALITY CASE OF BURAYU TOWN

BY: MERGA DUMESSA ETICHA

ADVISOR: DR-EN ZEBENE KIFLE

ATHESIS SUBMITTED TO THE GRAGUATE PROGRAM IN PARTIAL FULFILLMENT FOR THE AWARD OF DEGREE OF MASTER AT ADDIS ABABA SCIENCE AND TECHNOLOGY UNIVERSITY.

MAY, 2017

ADDIS ABABA, ETHIOPIA

DECLARATION

This thesis entitled "Assessment of the effect of human activities on groundwater quality" in Burayu, Oromia National Regional State, Ethiopia" is my original work and has not been presented for a Masters or any other Degree in AASTU or any other university.

Merga Dumessa	----------------------------	--------------------
Researcher	Signature	Date

Approved by

Dr-En Zebene Kifle	……………………..	……………………
Advisor	Signature	Date

ABSTRACT

Water is a chief natural resource essential for the existence of life and is a basic human entity. Therefore, water quality issues and its management options need to be given greater attention in developing countries. Water quality is influenced by natural and anthropogenic effects including local climate, geology and irrigation practices. Groundwater quality is based upon the physical and chemical soluble parameters due to weathering from source rocks and anthropogenic activities in which human activities are the major.

Contamination of surface and groundwater is the most serious problems affecting the health of the population. The study was conducted to assess the effect of human activities on ground water quality in Burayu town, Oromia National Regional State, Ethiopia. The study was to determine the basic Physical, chemical and biological parameters of groundwater and to assess source of contaminants of the ground water for drinking purpose. Five samples were collected by purposive sampling technique and analyzed for various parameters. To show the assessed effect of human activity interpretation of all water chemistry data were carried out using Microsoft excels (Version 2007). The analyzed data was presented by using table, graphs/ column Chart. Compared with WHO guideline values for drinking water, pH range 6.2 to 8.3 fell between the ranges of 6.5 to 8.5).But the wells which locate around high human activity are relatively in basic or acidic media due to different chemicals and wastes are released /discarded to the area.

Turbidity (0.58 to 1 NTU), which indicates that the acceptable levels of turbidity with the WHO recommended limit of 5 NTU in all locations. EC (193.7 to 345 µS/cm), which was greater than the WHO recommended limit of 250 mg/l. Iron concentrations is lower than the WHO stipulated limit of 0.30mg/L in all locations. The bacteriological analysis also revealed that all the water sources contained high Fecal and Total Coli form counts ranging 9 to 40 and 300 to 400cfu/100 ml respectively. Here the effect of human activity is visible comparing well location and activity around the area. This implies that human effect such as industrial effluents, improper waste disposal and liquid wastes released from different sectors of the town are the main activities affects groundwater quality and Consumption of contaminated water from water sources may cause public health problems.

Key words: *GW quality, GW quality parameters, WHO, ES, GPS, GIS, Total coli form, Fecal coli form, Burayu, Oromia.*

ACKNOWLEDGMENTS

First of all, I would like to thank Almighty God for His protection and guidance in all aspects of my life. I would like to express my gratitude to my advisor Dr-Enr Zebene Kifle for his guidance and endless support throughout this study,for his encouraging, valuable feedback and insight that have greatly influenced and accelerated this study. I would like to extend my great appreciations to Dr Sisay. for his close, patience, advice and constructive suggestions from the start to the completion of the research.

I would like to extend my thanks to Ethiopian Road Authority, AASTU for their support. My next gratitude goes to my friends for their material Support and moral encouragement throughout the study period.

Last but not least, I am very grateful to have a great family with enormous support, love and appreciation which gave me strength on my way.

LIST OF FIGURES

LIST OF TABLES

REFERENCES

Addis Ababa Central Statistical Agency, 2010. Waste to energy project proposal.

Anonymous, 2008. Assessment of surface water for drinking quality. Directorate of Land Reclamation Punjab, Irrigation and Power Department, Canal Bank, Mughalpura, Lahore, Pakistan.

American Public Health Association, 1995. Standard Methods for the Examination of Water and Waste, 14th Edition Washington D. C. Pp. 76-265

Appelo, C.A.J. and D. Postma (2005). Geochemistry: Groundwater and pollution. 2nd Ed. Balkema, Rotterdam.

AYERES R. S and WESTCOT D.W, 1994. Water quality for agriculture. FAO Irrigation and Drainage Paper.

AYERES R.S (1976). Water Quality for Agriculture. Food and Agricultural Organization of the United Nations, Rome. Irrigation and Drainage paper, No. 29.

Balakrishnan, P., Saleem, A., and N. D. Mallikarjun , 2011. Groundwater quality mapping using geographic information system (GIS): A case study of Gulbarga City, Karnataka, India. African Journal of Environmental Science and Technology, Vol. 5, No. 12, Pp: 1069-1084.

Babu, K.N., Padmalal, D., Maya, K., Sreeja, R. and Arun, P.R, 2007. Quality of Surface and Ground Water Around Tile and Brick Clay Mines in the Chalakudy River Basin, Southwestern India. Jour. Geol. Soc. India, Vol.69, Pp: 279-284.

Barcelona, M. J., Gibb, J. P., Helfrich, J.A., et al, 1985. Practical guide for groundwater sampling (E. a. N. Resources, Trans.) (Pp. 103): Illinois State Water Survey.

Bartran, J. and R. Balance, 1996. Water Quality Monitoring: A Practical Guide to the Design and Implementation of Fresh Water Quality Studies and Monitoring Programmes. E and F.N. Spoon: London, UK.

Bear J., 1979. Hydraulics of Groundwater. McGraw-Hill International Book, New York

CAWST, 2013. Introduction to Drinking water Quality Testing.

Central ground water board ministry of water resources government of India, 2010. Ground water quality in shallow aquifer of India.

Chilton. J, 1996.Water Quality Assessments : A Guide to Use of Biota, Sediments and Water in Environmental Monitoring **.** UNESCO/WHO/UNEP, Second Edition.

Crossgrove, J. and W. Zheng, 2004. Manganese toxicity upon overexposure. NMR Biomedicine, Vol. 17, Pp: 544–553.

Doneen, L.D., 1964. Water quality for agriculture. Department of Irrigation, University of Calfornia, Davis, 48.

Doria M. D. F, 2010. Factors influencing public perception of drinking water quality. water policy Vol.12, Pp: 1-19.

Eaton, F.M., 1950. Significance of carbonate in irrigation waters. Soil Science, Vol. 69, Pp: 123-133.

Elton, N.W., W.J. Elton and J.P. Narzareno, 1963. Pathology of acute salt poisoning in infants. American Journal of clinical pathology, Vol. 39, Pp: 252-264.

Emsley, J., 2003. Manganese. Nature's building blocks: an A–Z guide to the elements, USA: Oxford University, Pp: 249-253.

Fetter, CW.,1994. Applied Hydrogeology**,** Third Eddition. Prentice Hall, New Jersy.

Freeze, R. A., Cherry, J. A., 1979. Groundwater: Prentice Hall Inc, New Jersey

Gadgil A., 1998. Drinking water in developing countries. Lawrence Berkeley National laboratory,environmental energy technologies division, 1 Cyclotron Road, California, s.1.

Gupta, D. P., Sunita and J. P. Saharan, 2009. Physiochemical Analysis of Ground Water of Selected Area of Kaithal City (Haryana) India, Researcher, 1(2), Pp: 1-5.

HARTER T., 2003. Groundwater Quality and Pollution. FWQP Reference Sheet 11.2, University of California.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Hounslow, A. W., 1995. Water quality data; analysis and interpretation.Unite States of America: LEWIS.

Iliopoulos, V., Stamatis, G.,and Stournaras, G.,2011. Marine and human activity effects on the groundwater quality of Thriassio Plain, Attica, Greece. [Advances in the Research of Aquatic Environment]. Environmental Earth Sciences, Pp: 409-419.

Jensen, P.K., J.H.J. Ensink, G. Jayasinghe, W. Van der Hoek, S. Cairncross and A. Dalsgaard, 2003. Effect of Chlorination of Drinking-water on Water Quality and Childhood Diarrhoea in a Village in Pakistan. 21, Pp:26-31.

Joshi, D.M., A. Kumar and N. Agrawal, 2009. Assessment of the irrigation water quality of River Ganga in Haridwar District. Rasayan journal of chemistry, 2(2), Pp: 285-292.

Karthikeyan.N, Saranya.A,and Sashikkumar M.C., 2013. Spatial analysis of Ground water quality for virudhunagar district, Tamil Nadu Using GIS.

Kebede T. and Tadesse H.M., (1990). Engineering Geological Map of Addis Ababa, EIGS (unpublished report)

Khodapanah, L., W.N.A. Sulaiman and N. Khodapanah, 2009. Groundwater Quality Assessment for different Purposes in Eshtehard District, Tehran, Iran. European Journal of Scientific Research, 36(4), Pp: 543-553.

Madrid, Y., and Zayas, Z. P., 2007. Water sampling: Traditional methods and new approaches in water sampling strategy.

Mazor, E.,1991. Applied Chemical and Isotopic Groundwater Hydrology. USA, Canada and Latin America: HALSTED PRESS.

Michael H., 2006. Drinking water quality assessment and treatment in east Timor a case study: Tangkae, the University of East Timor.

Mirabbasi, R., S.M. Mazloumzadeh and M.B. Rahnama, 2008. Evaluation of irrigation water quality using fuzzy logic. Research Journal of Environmental Sciences, Vol. 2, No.5, Pp: 340-352.

Muhammad, M., Samira, S., Fayal, A., & Farrukh, J., 2013. Assessment of Drinking Water Quality and its impact on Residents Health in Bahawalpur City. *International Jornal of Humanities and Social Science*, Vol.3, No.15.

Nickson, R. T., McArthur, J. M., Shrestha, B., Kyaw- Nyint, T.O., Lowry, D., Arsenic and other drinking water quality issues, Muzaffargarh District. Pakistan Applied Geochemistry, Pp: 55–68, 2005.

Patil, P. R., Badgujar, S. R., and Warke A. M. 2001. Oriental J Chem. 17 (2), Pp: 283.

Patil, V.T., and Patil, P.R., 2010. Physicochemical Analysis of Selected Groundwater Samples of Amalner Town in Jalgaon District, Maharashtra, India. E-Journal of Chemistry. 7(1), Pp: 111-116.

Raghunath, M., 1987. Groundwater, 2nd Ed., Wiley Eastern Ltd., New Delhi, India.

Ramesh.K and Elango,L., 2011. Groundwater quality and its suitability for domestic and agricultural use in Tondiar river basin, Tamil Nadu, India, Environ Monit Assess DOI 10.1007/s10661-011-2231-3.

Reddy, K.S.S.N. and T.A. Reddy, 2011. Qualitative characterization of groundwater resources for irrigation: a case study from Srikakulam area, Andhra pradesh, India. International Journal of Engineering Science and Technology, 3(6), Pp: 4879-4887.

Sadashivaiah, C., C.R. Ramakrishnaiah and G. Ranganna, 2008. Hydrochemical Analysis and Evaluation of Groundwater Quality in Tumkur Taluk, Karnataka State, India. Int. J. Environ. Res. Public Health, 5(3): 158-164

Simeonov, V., Stratis, J. A., Samara, C., Zachariadis, G., Voutsa, D., Anthemidis, A., Sofoniou, M. and Kouimtzis, T.H., 2003. Assessment of the surface water quality in Northern Greece. Water Research, Vol.37, Pp: 4119–4124.

Shahnawaz, M., and Singh K. M. 2009. Ground Water Quality of Piro and Jagdishpur Blocks of Bhojpur District: A Middle Gangatic Plain. International Journal of Pharmaceutical

Quality Assurance. 1(1):9-12.Sheat A., 1992. Public perception of drinking water quality. Should we care? Paper presented at the New Zealand Water Supply and Disposal Association Annual Conference. Cited in Syme & Williams (1993). Slovic, P. (2000). The Perception of Risk. Earthscan, London.

Sreedevi, P.D. Groundwater quality of Pageru river basin, Cuddepah district Andhra Pradesh. J. Goel. Soc. India, Vol.64 (5), 2004: pp.619– 636.

Stevens M., Ashbolt N. and Cunliffe D. (2003). Recommendation to change the use of coli form as microbial indicators of drinking water quality. Australia Government National Health and Medical Research Council.

Subba Rao, N., 2006. Seasonal variation of groundwater quality in a part of Guntur District, Andhra Pradesh, India. Journal Environ Geol 49: 413–429.

Thorne, D.W. and H.B. Peterson, 1954. Irrigated soils, London: Constable and Company.

Todd DK. 1980. Groundwater hydrology [M], 2nd edn. Wiley, New York, p 535.

Trivedy, R.K. and P.K. Geol, 1984. Chemical and biological methods for water pollution studies. Karad: Environ Publications.

TWDB (Texas Water Development Board), 2002, People and groundwater.Water for Texas.Texas Water Development Board, Document no.GP-7-1, Austin, Texas, 156 pp. <http://www.esi.utexas.edu> (accessed on 29 November 2008).

UNEP , 2003. Groundwater and its susceptibility to degradation: A global assessment of the problem and options for management.

UNICEF, 2008. UNICEF hand book on water quality. United Nations Children's Fund

(UNICEF), New York.

Van Koppen, B., Moriarty, P., Boelee, 2006. Multiple-Use water Services to Advance the Millennium Development Goals. Research Report 98, IWMI, Colombo Sri Lanka.

WHO, 2011. Guidelines for Drinking-Water Quality, Fourth Edition. WHO,Geneva,

Switzerland.

Wilcox L.V., The quality of water for irrigation use vol. 40. US Department of Agriculture Technology Bulletin 962, Washington DC, 1948.

Wubshet Hirpasa, 2015. Investigation on the Engineering Processes of Soil found in Burayu Town.

ZHANG H., 1990. Classification of Irrigation Water Quality. Oklahoma State University Soil, Water and Forage Analytical Laboratory. Oklahoma Cooperative Extension, Factsheet PSS-2401-4.

ANNEXES

Annex 1.)

1A. Temperature, Electrical Conductivity, P^H, TDS and Dissolved oxygen determination

Temperature, conductivity, pH, TDS and DO of the water samples were determined with a multi parameter probe. The meter was calibrated prior to use with 0.001 N and 0.10 N standard potassium chloride solutions (according to the manufacturer's specifications) and buffer standards of pH 4, 7 and 9.2 at room temperature. The analysis involved dipping the probe of the meter directly into 100 ml water sample measured in a beaker, then taking the reading as displayed on the screen of the equipment. After each measurement, the probe was rinsed in distilled water and the display mode adjusted to the standardization value for measurement of the next parameter.

1B.) Turbidity Determination:

Turbidity was determined using the Nephelometric method (APHA, 1998) with turbidity meter in which the sample was shaken vigorously and transferred into a sample cell to at least two-thirds full. The sample cell was placed in the turbid meter and the appropriate range on the turbid meter was selected. The stable turbidity reading was then recorded.

1C.) Chloride Determination:

For the determination of Chloride, Mohr's argentometeric titration method was used.

One ml potassium chromate was added in 20 ml sample in a 250 ml conical flask and the solution turns yellow in color. The solution was titrated with 0.0141N $AgNO_3$ till the first brick red appears. This was the end point and noted down the volume of $AgNO_3$ added (V_s).

Blank titration :

- ❖ 1ml potassium chromate was added in 20 ml distilled water in a 250 ml conical flask and the solution turns yellow in color. The solution was titrated with 0.0141N $AgNO_3$ till the first brick red appears. This was the end point and noted down the volume of $AgNO_3$ added for distilled water (V_b).
- ❖ Calculation :

$$\text{Chloride (mg/l)} = \frac{(Vs-Vb) \text{ x Nx}1000 \text{ x}35.45}{S} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

Where; V_s = volume of $AgNO_3$ for sample

V_b = volume of $AgNO_3$ for blank

S = volume of sample (ml)

1D. Total Hardness Determination:

A 20 ml sample was measured into a 250 ml conical flask. To this was added 5 drops of buffer solution and was then followed by the addition of 4-5 drops of erichome black-T was mixed. The mixture was titrated with 0.02 N EDTA solutions until the wine red color of the solution changed to blue (end point) and noted down the burette reading.

Calculation: Total hardness (mg/L) = $\frac{\text{Tx N x } 50 \text{ x } 1000}{V}$ ………………………………….. (3.2)

Where; T = volume of EDTA

N = Normality

V = volume of sample

1E. Total Alkalinity Determination

A 50 ml of sample was pipette into a conical flask and 4-6 drops of phenolphthalein indicator was added in the solution and finally 3 drops of bromocresol was mixed with it respectively. In the samples, carbonates were absent as there was no color change appeared after addition of phenolphthalein indicator. To the same flask, 4 drops of methyl orange was added and titrated with 0.02N H_2SO_4 continued until the color changed from yellow to brick red which was the end point of bicarbonate and jot down the value (V_2).

Calculation:

$$\text{Total alkalinity (mg / L)} = \frac{\text{Volume of sulphuric acid (V2)x N x 50 x 1000}}{\text{Volume of sample taken}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3.3)$$

$$HCO_3^- \text{ as mg } CaCO_3 \text{ /L} = \frac{T-(5*10^{(PH-10)})}{1+0.94*10^{(PH-10)}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3.4)$$

$$CO_3^{2-} \text{ as mg } CaCO_3 \text{ /L} = 0.94*HCO_3^- *10^{(PH-10)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3.5)$$

Where: T = total alkalinity as mg $CaCO_3$/l

Determination of Bicarbonate and Carbonate (Standard Analytical Procedures for Water Analysis, May 1999).

Alkalinity result	Bicarbonate, mg $CaCO_3$/L	Carbonate, mg $CaCO_3$/L
P = 0	T	0
P < ½T	T-2P	2P
P = ½T	0	2P
P > ½T	0	2(T-P)
P = T	0	0

Where; P = Phenolphthalein alkalinity

T = Total alkalinity

1F. Sulfate Determination

The water sample was checked with qualitative test whether the concentration of the sulfate exists or not before going to measure by UV-Spectrophotometer.

Qualitative test:

Two ml of the 37% HCl and 5ml of 10% $BaCl_2$ was added to 7ml water sample respectively. The sample was heated on flame to identify the existence of sulfate concentration in the water sample until white precipitation appeared. Finally the end result was white precipitation appeared, and then analysis indicate that sulfate concentration in the sample.

1G. Determination of Calcium ($Ca^{2+)}$ and Magnesium (Mg^{2+})

50 ml of water sample was diluted to 50 ml such that the calcium content was 5 - 10 mg. Samples which contain alkalinity greater than 300 mg/L was neutralized with acid and boiled for 1 minute and cooled before titration. 2 ml NaOH solution was produced a pH of 12 to 13 and the titration was immediately started after addition of the alkali and then 0.1 - 0.2 indicators was added. Finally, titrated with EDTA solution, with continuous mixing, till the color was changed from pink to purple. The end point was checked by adding 1 to 2 drops excess titrant to make certain that no further color change occurs.

Calculation:

$$\text{Ca (mg / L)} = \frac{\text{A x B x 400.8}}{\text{V}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.6)}$$

$$\text{Calcium hardness as } CaCO_3 \text{ (mg / L)} = \frac{\text{A x B x 1000}}{\text{V}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.7)}$$

Where; A = ml titrant for sample

$$\text{B} = \frac{\text{mL of standard calcium solution taken for titration}}{\text{mL EDTA titrant}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(3.8)}$$

Mg (mg/L) = (Total Hardness as mg CaCO3/L - Calcium Hardness as mg CaCO3/L) x 0.243

1H. Determination of Sodium (Na^+) and Potassium (K^+)

Sodium:

A blank and Sodium calibration standards was prepared in the ranges of 0-100, 0-10, or 0-1 mg Na/L. The instrument was set zero with standard containing no sodium and measured emission at

589nm and calibration curve was also prepared. The sodium concentration of the sample was determined from the curve.

Calculation:

Mg Na/L = mg Na/L from the calibration curve × Dilution ……………………….…….. (3.9)

Where: Dilution = $\frac{\text{ml sample+ml distilled water}}{\text{ml sample}}$ ………………………………….......... (3.10)

Potassium:

A blank and Potassium calibration standards was prepared in the ranges of 0-100, 0-10, or 0-1 mg K/L. The instrument was set zero with standard containing no potassium and measured emission at 766 nm and calibration curve was also prepared. The Potassium concentration of the sample was determined from the curve.

Calculation:

Mg K/l = mg K/l from the calibration curve × Dilution…………………….....… (3.11)

Where; Dilution = $\frac{\text{ml sample+ml distilled water}}{\text{ml sample}}$ ………………………………….…… (3.12)

1I. Analysis of Iron and Manganese:

The concentrations in mg/L of two metals were determined in the samples namely, Fe and Mn with the Atomic Absorption Spectrophotometer(Perkin Elmer Analyst 400). The flame used for the analysis was air-acetylene mixture. A 100ml stock solution of two elements solution was obtained from the laboratory. Standard solutions ranging from 0.2 to 5.0mg/l were prepared for calibration curves of those metals. A blank analysis was performed with distilled water treated to the sample treatment. The following concentrations of metal solutions were prepared to determine the baseline absorbance value at Fe: 5.5 mg/l and Mn: 10 mg/l. The metal concentrations were determined one after the other using their respective hollow cathode lamps (HCL) and calibration curves. Air-acetylene wave flame was used for the analysis. The respective wavelengths employed for the metal determinations were Fe at 248.7 nm and Mn at 525 nm.

1J. Microbiological analysis of water samples:

Fecal coliform and total coliform bacteria were determined using the membrane-filter technique (APHA, 1992). One hundred milliliters of each sample were aseptically filtered through sterile 0.45µm-pore size membrane filters (Whatman) and the filters transferred onto agar nutrient (MacFaddin, 1985) with rosolic acid in glass Petri dishes for Coliform. Petri dish was closed and labeled at the top of the lid with code number of the water sample and incubated at 37^{0}C for 24 hr. Upon completion of the incubation period typical blue colored for Fecal Coliform and both red and blue colony for Total coliform bacteria.

Annex 2

A) Results of the physical analysis of groundwater sample for the study areas.

Parameters	Result of the sample areas				
	L_1	L_2	L_3	L_4	L_5
PH	5	5.2	6.5	7.8	8.3
EC	193.7	215	240	345	352
TDS	96.8	110	90	98	176
Turbidity	0.58	0.6	0.6	1	0.71

Annex 3

A) Results of the chemical analysis of groundwater sample for the study area

Parameters8	Result of Sample areas				
	L_1	L2	L_3	L_4	L_5
Cl^-	13.5	12.5	10.5	16	18.5
SO_4^{-2}	0.6	0.73	0.48	1.92	1.32
TH	21.9	24	27	19.9	4.3
TA	110	90	120	150	195
NO_3^-	1.94	3	4.86	1.16	0.16

HCO_3^-	110	90	120	150	195

Annex 4

A) Results of the metal analysis of groundwater sample for the study area

Parameters	Results of the study areas				
	L_1	L_2	L_3	L_4	L_5
Ca^{+2}	6.5	6.74	7.4	5.26	1.4
Na^{+1}	6.93	7.74	5.49	23.2	20.11
K^{+1}	5.09	5.38	1.34	2.45	5.81
Mg^{+2}	1.38	1.75	2.07	1.63	0.17
Fe^{+2}	0.02	0.05	0.1	0.03	0.08

Annex 5

A) Results of Bacteriological quality of the groundwater samples for the study area

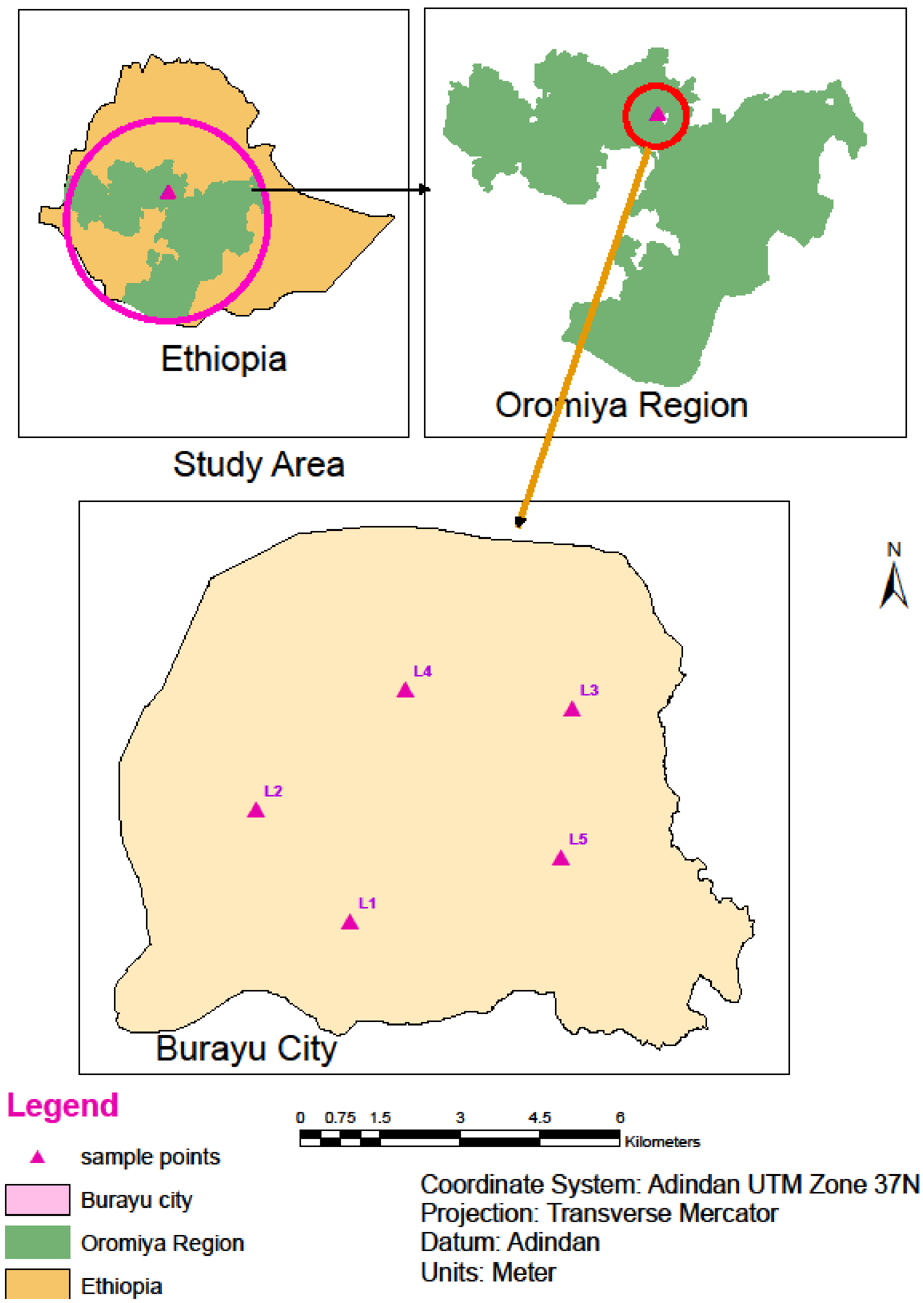
Parameters	Result of study areas				
	L_1	L_2	L_3	L_4	L_5
Fical coliform(cfu/100ml)	40	36	9	10	35
Total coliform(cfu/100ml)	400	375	300	394	305

Annex 6) photos during sampling time

Annex 7) Libratory photos

Annex. 8

A.) Map of the study area



LIST OF ABBREVIATIONS

AASWRDO	Addis Ababa Solid Waste, Recycling and Disposal Office
APHA	American Public Health Association
CAWST	Center for Affordable Water and Sanitation Technology
CGWB	Central Ground Water Board
DO	Dissolved Oxygen
EC	Electrical Conductivity
EPA	Environmental Protection Agency
FC	Fecal Coli form
GPS	Global Positioning System
GW	Ground Water
M	Meter
Mg/l	Milligram per liter
Ml	Millimeter
NTU	Nephelometric Turbidity Units
OWWDSE	Oromia Water Works Design and Supervision Enterprise
pH	Power of Hydrogen
SSP	Soluble Sodium Percentage
TA	Total Alkalinity
TC	Total Coli form
TDS	Total Dissolved solids
TH	Total Hardness
TWDB	Texas Water Development Board
UNEP	United Nations Environment Program
UNICEF	United Nations Children’s Fund
WHO	World Health Organization
µS/cm	Micro Siemens per centimeter

TABLE OF CONTENT

CONTENT **PAGE**

CHAPTER ONE

1. INTRODUCTION

1.1. Background and Justification

Water is one of the most important commodities which man had exploited than any other resources for sustenance of his life. It is a chief natural resource essential for the existence of life and is a basic human entity. Therefore, water quality issues and its management options need to be given greater attention in developing countries. Water quality is influenced by natural and anthropogenic effects including local climate, geology and irrigation practices (Ramesh & Elango, 2011). Groundwater quality is based upon the physical and chemical soluble parameters due to weathering from source rocks and anthropogenic activities. Groundwater quality reflects inputs from the atmosphere, soil and water rock reactions as well as pollutant sources such as mining, land clearance, agriculture, and acid precipitation, domestic and industrial wastes (Appelo and Postma, 1993). Suitability of water for various uses depending on type and concentration of dissolved minerals and groundwater has more mineral composition than surface water (Mirribasi et al., 2008). The quality of groundwater is constantly changing in response to daily, seasonal and climatic factors. Continuous monitoring of water quality parameter is highly crucial because changes in the quality of water has far as reaching consequences in terms of its effects on man and biota.

Similar to other areas of the world, groundwater is the major source of drinking water in Ethiopia. More than 80% of the country's drinking water supply source is from ground water. This includes more than 25 major cities in the country, (Kebede T. et al.,2004). Groundwater is an important source in Burayyu town. It supplies drinking water and water for domestic uses, livestock watering and, to some extent, for agricultural purposes. Now a day the need for groundwater utilization is likely to increase due to expansion of irrigated agriculture and different development activities within the surrounding areas. Water quality data is essential for the implementation of responsible water quality regulations for characterizing and remediating contamination and for the protection of the health of humans and the ecosystem.

Regular monitoring of groundwater resources plays a key role in sustainable management of water resources in addition to minimize water related diseases caused by insufficient safe water supplies coupled with poor sanitation and hygiene which cause 3.4 million deaths a year.

Most of these societies are children. Over a billion people still do not have access to improved water sources (UNICEF, 2008). The World Health Organization estimated that up to 80% of all sicknesses and diseases in the world are caused by inadequate sanitation, polluted water or unavailability of water. In Ethiopia over 60% of the communicable diseases are due to poor environmental health conditions arising from unsafe and inadequate water supply and poor hygienic and sanitation practices (WHO, 2004).

Several studies have confirmed that water-related diseases not only remain a leading cause of morbidity and mortality worldwide but that the spectrum of diseases is expanding and the incidence of many water-related microbial disease is increasing (WHO, 2003). Diarrhea remains a major killer in children and it is estimated that 80% of all illness in developing countries is related to water and sanitation; and that 15% of all child deaths under the age of 5 years in developing countries results from diarrheal diseases, (WHO, 2003).

In rural areas and villages of Ethiopia, water for human consumption, drinking, washing (bathing, laundry), for preparation of food etc, is obtained from rivers, streams, shallow wells, springs, lakes, ponds, and rainfall. *Burayu* town uses all sources list above even if GW is the main water source. Unless water is made safe or treated for human consumption; it may be hazardous to health and transmit diseases. The main contaminants of these water sources are human excreta, industrial waste, domestic waste, agricultural waste, animal waste and effluent because of open field defecation practices. Thus, the majority of rural communities use water from contaminated or doubtful sources, which expose the people to various water-borne diseases unless these sources are well known and treated, (MoWR, 2004). In developing countries sources of pollution from domestic, agricultural, industrial activities are unregulated (UNEP, 2005). Further intensive study of the concerned area is required to have a detailed examination of groundwater quality for drinking, industrial purpose, irrigation and other uses.

Since the investigator is parts of this society and becomes one of the dis-advantageous groups; this burning issue deals with and wants to see the problem from its grass root level. Again there is no research that has been attempt on this topic in this area that is the other goal of the researcher to focus on this topic.

Thus, this study seeks and serves as a preliminary study to assess effect of groundwater quality for drinking and other purposes for a rapidly developing community located in Burayu town.

1.2. Statement of the problem

According to the Central Statistical Agency, the population of Burayu town is about 200,000 inhabitants in 2010, (AACSA, 2010). Know a days the population of the areas estimated to around 300,000 inhabitants. Most of the activities in and around the town include agricultural, industrial and commercials. All of these activities release contaminants to the environment which eventually end up in the groundwater. In particular, inadequacy of the solid waste management and effluents released from industries are the major environmental issue especially for pollution of water sources. Most of the society of the Burayu uses tap water which is directly received from the GW source, even if some of river and surface water sources are used.

Some health problems related to consumption of inadequately treated water are also reported in the town. These situations mostly expose the population of the area to water related disease such as diarrhea and colera.

Hence, there is always a need for and concern over the protection and management of groundwater quality (Patil et al., 2001)**.** In this study an attempt will be made to assess the effect of human activity on the ground water quality in Burayu town.

1.3. OBJECTIVE OF THE STUDY

1.3.1. General Objective

The general objective of the study is assessment of the effect of human activities on groundwater quality in Burayu town, Oromia Regional State, Ethiopia.

1.3.2. The specific objectives

To determine the main contaminants released affecting GW sources

To characterize the GW water quality parameters such as TDS, pH, conductivities, total hard ness, etc. at different sites and compare with international standards.

1.4. Hypothesis/Research Question

Are human activities the main causes of contamination of ground water?

.Which types of contaminant sources are mainly affecting GW at the areas?

1.5. Significance of the study

The study will contribute to improve the understanding of the factors that affect groundwater quality for drinking uses. The generated data will contribute for the sustainable management of groundwater resources in the study area.

This helps to understand and implement groundwater quality management strategies. The information generated can represent an important preliminary tool in decision making pertaining to the management of groundwater quality. This study may have undeniable importance in revealing the hidden problems and understanding the ongoing human activities in the study area, besides defining the status and magnitude of impact on the environment. The investigator also optimistically believes that, the primary beneficiary of this research output will be the community in the study area in general and government body in particular. Finally it will help as a reference for practitioners who are interested to investigate this issue in the future. Furthermore it will serve as a lighting house for future researches in this particular area.

1.6. Scope of the study

The scope of the study is limited to determine the main contaminants released affecting GW sources and to characterize the GW water quality parameters such as TDS, pH, conductivities, total hardness, etc. at different sites and compare with international standards.

It did not cover all water wells in the area due to resource and time limitations. Some difficulties were faced in accessing data and resources from the local authorities. The overall quality assessment of groundwater in this study depends on chosen physical and chemical parameters. The detail information regarding the groundwater construction was unknown. There may be seasonal variation because study was done during the dry season.

CHAPTER TWO

2. LITRATURE REVIEW

2.1. Water Quality

2.1.1. Water Quality Definition

The concept of water quality is complex because so many factors influence in it. In Particular, this concept is intrinsically tied to the different intended uses of the water; different uses require different criteria. Water quality is one of the most important factors that must be considered when evaluating the sustainable development of a given country, (Doria M. D. F, 2010).

Water quality must be defined based on a set of physical and chemical variables that are closely related to the water's intended use. For each variable, acceptable and unacceptable values must then be defined. Water whose variables meet the pre-established standards for a given use is considered suitable for that use. If the water fails to meet these standards, it must be treated before use. Water quality is considered the main factor for controlling health and the state of disease in both woman and animal (Doria M. D. F, 2010).

According to Hounslow (1995), water quality is defined by the physical, chemical and biological characteristics and a composition of water sample. The chemical composition of groundwater is the combined result of water composition that enters the groundwater reservoir and the reactions with minerals present in the rocks (Iliopoulos et al., Zhu, 2002). The quality of water varies due to variation both in the natural geological and hydro geological conditions and human impact. Water rock interaction plays an important role in controlling water quality. The main mineral characteristics of water, especially groundwater are determined by weathering reaction taking place close to the earth's surface and there is a wide diversity of chemical composition related to the geology of the catchment or aquifer. The primary purpose of water analyses is to determine the suitability of water for a proposed use. The three main classes of use are domestic, agricultural and industrial.

2.2. Groundwater Quality and Sources of Pollution

2.2.1. Concept of Ground Water Quality

The concept of ground water quality seems to be clear, but the way of how to study and evaluate it still remains tricky (Chilton. J, 2009).

Consider that the definition of water quality is not objective, but is socially defined depending on the desired use of water. Different uses require different standards of water quality.

2.2.2. Ground water Resource

Ground water is resource found under the land surface in the saturated zone. It constitutes about 95 percent of the freshwater on our planet (discounting that locked in the polar ice caps). Most of the Earth's liquid freshwater is found, not in lakes and rivers, but stored underground in aquifers. These aquifers provide a valuable base flow supplying water to rivers during periods of no rainfall. Therefore it is an essential resource that requires protection, (UNEP, 2003).

2.3. Water Quality Standards Guidelines

2.3.1. The Guidelines for drinking-water quality

The Guidelines describe reasonable minimum requirements of safe practice to protect the health of consumers and/or derive numerical "guideline values" for constituents of water or indicators of water quality. In order to define mandatory limits, it is preferable to consider the guidelines in the context of local or national environmental, social, economic and cultural conditions (WHO, 2008).

2.3.2. The Standard for drinking-water quality

By definition, a standard is "a rule or principle considered by an authority and by general consent as a basis of comparison. It is something normal or average in quality and the most common form of its kind". A proper standard for drinking water quality is thus the reference that will ensure that the water will not be harmful to human health. The framework against which a water sample can be considered good or "safe" is a drinking water quality standard (Solsona F., 2002).

2.3.3. WHO Guidelines

The primary purpose of the Guidelines for Drinking-water Quality is the protection of public health. Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking-water, (WHO, 2008). WHO standard divided drinking water guidelines according to the following aspects.

a. **Microbial aspects**: In general terms, the greatest microbial risks are associated with ingestion of water that is contaminated with human or animal (including bird) faeces.

Faeces can be a source of pathogenic bacteria, viruses, protozoa and helminthes. Faecally derived pathogens are the principal concerns in setting health-based targets for microbial safety, (WHO, 2008).

Drinking-water-borne outbreaks are particularly to be avoided because of their capacity to result in the simultaneous infection of a large number of persons and potentially a high proportion of the community, (WHO, 2008).

b. Chemical aspects

The health concerns associated with chemical constituents of drinking-water differ from those associated with microbial contamination and arise primarily from the ability of chemical constituents to cause adverse health effects after prolonged periods of exposure. There are few chemical constituents of water that can lead to health problems resulting from a single exposure, except through massive accidental contamination of a drinking-water supply. Moreover, experience shows that in many, but not all, such incidents, the water becomes undrinkable owing to unacceptable taste, odour and appearance, (WHO, 2008).

c. Radiological aspects:

The contribution of drinking-water to total exposure to radionuclide is very small under normal circumstances,(WHO ,2008).While finding levels of activity above screening values does not indicate any immediate risk to health, it should trigger further investigation into determining the radionuclide responsible and the possible risks, taking into account local circumstances,(WHO , 2008).

d. Acceptability aspects (Aesthetics aspects): Water should be free of tastes and odor that would be objectionable to the majority of consumers. In assessing the quality of drinking-water, consumers rely principally upon their senses. Microbial, chemical and physical water constituents may affect the appearance, odor or taste of the water and the consumer will evaluate the quality and acceptability of the water on the basis of these criteria. Although these substances may have no direct health effects, water that is highly turbid, is highly colored or has an objectionable taste or odor may be regarded by consumers as unsafe and may be rejected, (WHO, 2008)

2.4. Source of Ground Water Pollution

Groundwater quality is a hidden issue inside a hidden resource, and as a result far too little attention is given to it.

Once groundwater has become polluted, it is usually a very long, complex and expensive task to restore the water quality. For these reasons monitoring, prevention and remediation of groundwater pollution is a vital management issue (UNEP, 2003).

Quality of groundwater is affected by both natural influences and *human activities*. Even if water contains natural contaminants, it is becoming more and more polluted by human activities such as, inadequate wastewater management, dumping of garbage, poor agricultural practices, and chemical spills at industrial sites (CAWST, 2013).

Figure: 2.1. Some pollutants of anthropogenic sources

Figure: 2.2. Sources of waste and how it leaches to aquifer.

Groundwater flows easily through permeable layers (aquifers) like sand and gravel. Pathogens and chemicals which are suspended (mixed with) or dissolved in this groundwater also easily migrate (move) through permeable layer. Water with pathogen has to be stopped before reaching the surroundings of well-screen. To minimize this, selection of construction of wells should be studied by geologist to get impermeable soil layer. The other option is increasing the depth of the well to lose the pathogens life before reaching the groundwater face and optimize the filtration probability of in-flow run off or unfiltered liquid industrial wastes.

As per City Administration of Addis Ababa Solid waste Recycling and Disposal project office detail study the current estimates of the daily waste generation in Burayu town is approximately 86.01 MT, (AASWRDPO, 2014).

Waste disposal habit of the people , attitude to work, lack of adequate equipment, facilities and tools necessary for waste management, corruption, and a lack of resident participation are the poor management of waste from the point of generation to the final disposal.

The poor management consists of the practice of the waste generator of directly discarding waste into the environment; road sides, river banks or any open space.

The lack of properly designed containers/inadequate storage problem compounded by the improper handling and storage and non-observance of collection day schedule render it exceedingly difficult to maintain cleanliness and order in delinquent neighbor hoods.

The collection, transport, treatment, and disposal of solid waste is generally a difficult problem to solve in different towns of Oromia regional state and particularly in Burayu town.

These problems still remain a headache to the municipal offices in its management. This uncontrolled waste management leads to pollution of ground water since wastes are discarded everywhere and washed out to the water sources. Solid wastes have been consistent, dependent on sectors and activities (Tchobanoglous, et al., 1977), and these include the following sources.

Municipal Waste: This includes dust, leafy matter, building debris, treatment plant residual sludge, etc., generated from various municipal activities like construction and demolition, street cleaning, landscaping, etc. These all are sources of waste expected to pollute GW of the Burayu town and local areas.

Residential: This refers to wastes from dwellings, apartments, etc., and consists of leftover food, vegetable peels, plastic, clothes, ashes, etc.

Commercial: This refers to wastes consisting of leftover food, glasses, metals, ashes, etc., generated from stores, restaurants, markets, hotels, motels, auto-repair shops, Medical facilities.

Institutional: This mainly consists of paper, plastic, glasses, etc., generated from educational, administrative and public buildings such as schools, colleges, offices, prisons, etc.

Industrial: This mainly consists of process wastes, ashes, demolition and construction wastes, hazardous wastes, etc., due to industrial activities.

Agricultural: This mainly consists of spoiled food grains and vegetables, agricultural remains, litter, etc., generated from fields, orchards, vineyards, farms, etc.

Open areas: this includes wastes from areas such as Streets, alleys, parks, vacant lots, playgrounds, beaches, highways, recreational areas. The above listed and other related wastes are collectively the source of pollutant for ground water. Even though water may be clear, it does not necessarily mean that it is safe for us to drink and other use. The World Health Organization WHO (2011) divides the sources of chemicals into the following five groups.

- Naturally occurring
- Agricultural activities
- Industrial sources and human dwellings
- Water treatment
- Pesticides use for public Health

Table: 2.1. Sources Of Chemical Contamination of Groundwater (WHO, 2011).

Sources of chemical	Example	Common Chemicals
Natural occurring	Rocks and soils	Arsenic, Chromium, Fluoride, Iron, Manganese, Sodium, Sulfate, Uranium
Agricultural activities	Manure, fertilizer, intensive animal practice	Nitrate, Nitrite
Industrial Sources and human Dwellings	Mining, industrial process, sewage solid waste, urban runoff, fuel leakage	Nitrate, Cadmium, Cyanide, Copper,Lead, Nickel,Mercury
Water treatment	Water treatment chemicals, piping materials	Aluminium, Chloride, Iodide, Silver

2.5. Factors Affecting Water Quality

Water is vital to health, well-being, food security and socioeconomic development of mankind. Therefore, the presence of contaminants in natural freshwater continues to be one of the most important environmental issues in many areas of the world, particularly in developing countries, where several communities are far away from potable water supply. Low-income communities, which rely on untreated surface water and groundwater supplies for domestic and agricultural uses are the most exposed to the impact of poor water quality. Unfortunately, they are also the ones that do not have Assessment of groundwater quality analyses in Burayu and adequate infrastructure to monitor water quality regularly and implement control strategies**, (**Anonymous, 2008**).**

Human activities are the major factor determining the quality of the surface and groundwater through atmospheric pollution, effluent discharges, use of agricultural chemicals, eroded soils and land use, (Kazi et al., 2009). Environmental pollution, mainly of water sources, has become public interest.

The chemical Composition of ground water is controlled by many factors that include the composition of precipitation, mineralogy of the watershed and aquifers, climate and topography. These factors can combine to create diverse water types that change in composition spatially and temporally, (Chenini I and Khemiri S, 2009). Exploitation of groundwater resources beyond their potential renewal capacity, results in a hydrological deficit. Generally, this is expressed as a decline in groundwater levels but in coastal aquifers this may cause intrusion of seawater.

2.6. Description of Water Quality parameters

It is very essential and important to test the water before it is used for drinking, domestic, agricultural or industrial purpose. Water must be tested with different physic-chemical parameters. Selection of parameters for testing of water solely depends upon for what purpose we going to use that water and what extent we need its quality and purity. Water does content different types of floating, dissolved, suspended and microbiological as well as bacteriological impurities. Some physical test should be performed for testing of its physical appearance such as temperature, color, odor, pH, turbidity, TDS etc, while chemical tests should be perform for its dissolved oxygen, alkalinity, hardness and other characters.

For obtaining more and more quality and purity water, it should be tested for its trace metal, heavy metal contents and organic i.e. pesticide residue. It is obvious that drinking water should pass these entire tests and it should content required amount of mineral level. Only in the developed countries all these criteria's are strictly monitored. Due to very low concentration of heavy metal and organic pesticide impurities present in water it need highly sophisticated analytical instruments and well trained manpower. Water sample parameters are analyzed in a laboratory. Some parameters such as temperature, conductivity, dissolved oxygen, pH, TDS are determined in the field (Hounslow, 1995). Following different physico-chemical parameters and biological parameters are tested regularly for monitoring quality of water.

2.6.1. Physical parameters

Temperature: The temperature of water to a large extent determines the extent of microbial activity. Temperature is the measure of hotness or coldness of water measured either in degree Celsius or Fahrenheit by using a thermometer (APHA, 1985).

pH: pH is the most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH was positively correlated with electrical conductance and total alkalinity (Gupta 2009). The parameter pH (negative base-10 logarithm of hydrogen ion activity in moles per liter) is one of the most fundamental water-quality parameters. It is easily measured, indicates whether water will be corrosive or will precipitate scale, determines the solubility and mobility of most dissolved constituents, and provides a good indication of the types of minerals groundwater has reacted with as it flows from recharge to discharge areas or sample sites. For these reasons it is one of the most important parameters that describe groundwater quality. The pH of neutral (neither acidic nor basic) water varies with temperature. For example, the neutral pH of pure water at 25°C (77°F) is 7.0. The neutral pH of pure water at 30°C (86°F) and 0°C (32°F) is 6.9 and 7.5, respectively (Hem, 1985).

Turbidity: Turbidity is the cloudiness caused by particulate matter present in source water, re suspension of sediment in the distribution system, the presence of inorganic particulate matter in some groundwater or sloughing of bio-film within the distribution system (WHO, 2004).

Turbidity is the most important problem for the aesthetic value of water quality. Although it doesn't necessarily adversely affect human health, it can protect microorganisms from disinfection effects, can stimulate bacterial growth, and indicate problems with treatment processes (WHO, 2004). For effective disinfection, median turbidity should be below 0.1 NTU although turbidity of less than 5 NTU is usually acceptable to consumers (WHO, 2004).

Electrical Conductivity: Conductivity is the measure of capacity of a substance to conduct the electric current. Most of the salts in water are present in their ionic forms and capable of conducting current and conductivity is a good indicator to assess groundwater quality. Electrical conductivity is an indication of the concentration of total dissolved solids and major ions in a given water body.

Table.2.2. Classification of irrigation water based on Electrical Conductivity, (Richards, 1954).

Water class	EC(micromhos/cm)	Salinity Significance
Excellent	<250	Water of low salinity is generally composed of higher proportions of calcium, magnesium and bicarbonate ions.
Good	250-750	Moderately saline water, having varying ionic Concentrations
Permissible	750-2250	High saline waters consist mostly of sodium and chloride Ions
Doubtful	>2250	Water containing high concentration of sodium, bicarbonate and carbonate ions have high pH

It is temperature dependent and the international unit is Siemens per meter (Hounslow, 1995; Mazor, 1991).

Table above shows classification of irrigation water based on Electrical Conductivity, (Richards, 1954).

Dissolved Oxygen

DO is one of the most important parameter. Its correlation with water body gives direct and indirect information e.g. bacterial activity, photosynthesis, availability of nutrients, stratification etc. (Premlata Vikal, 2009). In the progress of summer, dissolved oxygen decreased due to increase in temperature and also due to increased microbial activity (Moss 1972; Morrissette 1978; Sangu 1987; Kataria, 1996). The high DO in summer is due to increase in temperature and duration of bright sunlight has influence on the % of soluble gases (O_2& CO_2). During summer the long days and intense sunlight seem to accelerate photosynthesis by phytoplankton, utilizing CO_2 and giving off oxygen. This possibly accounts for the greater qualities of O_2 recorded during summer (Krishnamurthy R, 1990).

Total Dissolved Solids (TDS)

TDS is a measure of the amount of material dissolved in water. This material can include carbonate, bicarbonate, chloride, sulfate, phosphate, nitrate, calcium, magnesium, sodium, organic ions, and other ions (UNICEF, 2008).

The total concentration of dissolved minerals in water is a general indication of the overall suitability of water for many types of uses (Karthikeyan *et al*, 2013).

2.6.2. Chemical parameters

Alkalinity

It is composed primarily of carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) alkalinity acts as a stabilizer for pH. Alkalinity, pH and hardness affect the toxicity of many substances in the water. Alkalinity is the presence of one or more ions in water including hydroxides, carbonates, and bicarbonates. It can be define as the capacity to neutralize acid. Moderate concentration of alkalinity is desirable in most drinking water supplies to stable the corrosive effects of acidity. However, excessive quantities may cause a number of damages. The WHO standards express the alkalinity only in terms of total dissolved solids (TDS) of 500 mg/l (Muhammad *et al*., 2013).

Total Hardness

Hardness in water is caused primarily by the presence of carbonates and bicarbonates of calcium and magnesium, Sulfates, chlorides and nitrates. The hardness of natural waters depends mainly on the presence of dissolved calcium and magnesium salts.

The total content of these salts is known as general hardness, which can be further divided into carbonate hardness (determined by concentrations of calcium and magnesium hydro carbonates), and non-carbonate hardness (determined by calcium and magnesium salts of strong acids). Hydro carbonates are transformed during the boiling of water into carbonates, which usually precipitate. Therefore, carbonate hardness is also known as temporary or removed, whereas the hardness remaining in the water after boiling is called constant. The total hardness of water classified in to three ranges (0-300 mg/l, 300-600 mg/l and > 600 mg/l) low, medium and high respectively (Karthikeyan *et al.*, 2013).

Chloride

Chloride is minor constituent of the earth's crust. Chloride is present in all natural waters, mostly at low concentrations. Chloride in drinking water originates from natural sources, sewage and industrial effluents, urban runoff containing salt, and saline intrusion (WHO, 2011). High concentration of chloride gives a salty taste to water and beverages and may cause physiological damages. It is highly soluble in water and moves freely with water through soil and rock (CGWB, 2010). High concentrations of Chloride can make water unpalatable and, therefore, unfit for drinking or livestock watering (UNICEF, 2008).

According to CGWB (2010) in ground water the chloride content is mostly below 250 mg/L except in cases where inland salinity is prevalent and in coastal areas.

Sulfate

Sulfate is a combination of sulfur (S) and oxygen (O). It occurs naturally in many soil and rock formations. In groundwater, most sulfates are generated from the dissolution of minerals, such as gypsum and anhydrite. Saltwater intrusion and acid rock drainage are also sources of Sulfates in drinking water. Man made sources include industrial discharge and deposition from burning of fossil fuels (WHO, 2011). Sulfate concentrations in natural waters are usually between 2 and 80 mg/L. High concentrations greater than 400 mg/L may make water unpleasant to drink (UNICEF, 2008).

Nitrate

The main source of nitrate in water is from atmosphere, legumes, plant remains and animal excreta (WHO, 2011). It also originates from sewage effluents, septic tanks and natural drains carrying municipal wastes. NH_4^+ from organic sources is converted to NO_3^- by oxidation. Because of this and its anionic form NO_3^- is very mobile in groundwater (Balakrishnan et al, 2011).

The concentration of nitrate in natural water is less than 10 mg/L. Water containing more than 100 mg/L is bitter to taste and causes physiological distress.

Fluoride

Fluoride contamination of groundwater is a serious problem in several countries spread throughout the world as ingestion of excess fluoride, most commonly, through drinking contaminated groundwater causes fluorosis. Mainly two factors are responsible for contamination of groundwater with fluoride geological and anthropogenic. Rock geochemistry has a major control on geological fluoride contamination. Physiological conditions of rock, like decomposition, dissociation and subsequent dissolution along with long residence time may be the responsible factors for fluoride leaching (Madhnure, 2006).

Among anthropogenic factors industrialization, urbanization and improper utilization of water resources are of prime importance, in case of the developing countries (Giesen, 1999).Long term ingestion of fluoride in high doses can lead to severe skeletal fluorisis (Susheela, 2001).

Figure: 2.3.Some water born diseases related fluoride and other chemicals

Sodium

All natural waters contain some sodium since sodium salts are highly water soluble and it is one of the most abundant elements on earth. It is found in the ionic form (Na^+), and in plant and animal matter (it is an essential element for living organisms). The WHO guideline limit for sodium in drinking water is 200 mg/l. However, groundwater concentrations frequently exceed 50 mg/l. Sodium is commonly measured from the water is to be used for drinking or agricultural purposes, particularly irrigation.

Potassium

Potassium (K^+) is found in low concentrations in natural waters since rocks which contain potassium are relatively resistant to weathering. However, potassium salts are widely used in industry and in fertilizers for agriculture and enter freshwaters with industrial discharges and run-off from agricultural land. Potassium is usually found in the ionic form and the salts are highly soluble. It is readily incorporated into mineral structures and accumulated by aquatic biota as it is an essential nutritional element.

Magnesium

Magnesium arises principally from the weathering of rocks containing ferromagnesian minerals and from some carbonate rocks.

Magnesium occurs in many organ metallic compounds and in organic matter, since it is an essential element for living organisms. Magnesium occurs typically in dark colored minerals present in igneous rocks such as plagioclase, pyroxenes, amphiboles, and the dark colored micas. It also occurs in metamorphous rocks, as a constituent of chlorite and serpentine (Perk, 2006). Magnesium is common in natural waters as Mg^{2+}, and along with calcium, is a main contributor to water hardness. Natural concentrations of magnesium in fresh waters may range from 1 to 100 mg/L (UNICEF, 2008).

Iron

Iron (Fe) is a naturally occurring metal that is widely present in groundwater. Iron can exists in either an oxidized (ferric) or reduced (ferrous) state.

At normal groundwater pH values, ferric iron is rapidly precipitated as an iron oxide, iron hydroxide, iron ox hydroxides (rust), or poorly crystalline to amorphous material. Under reduced conditions, however, ferrous iron is stable and will remain in groundwater. There is no EPA primary drinking-water standard for iron in water supplies because there are no identified, serious health threats posed by it. There is, however, a secondary standard of 0.3 mg/L for iron because iron concentrations above this level may produce objectionable odor, taste, color, staining, corrosion, and scaling.

Manganese

Manganese (Mn) is a naturally occurring cat ion that is widely present in groundwater supplies. Manganese can cause an undesirable taste as well as staining laundry when levels exceed 0.1 mg/liter. The presence of manganese may also lead to the accumulation of deposits in the piping system (WHO, 2004). There is no health-based guideline value set for iron but for manganese it is four times higher than the acceptable threshold of 0.1 mg/liter (WHO, 2004). Geochemically, manganese and iron behave similar, so high manganese concentrations can be expected from wells and springs that produce water with high iron concentrations.

There is no EPA primary drinking-water standard for manganese in water supplies because there are no identified, serious health threats posed by it.

There is, however, a secondary standard of 0.05 mg/L for manganese based on the fact that higher concentrations may produce objectionable odor, taste, color, corrosion, and staining.

2.6.3. Bacteriological parameters

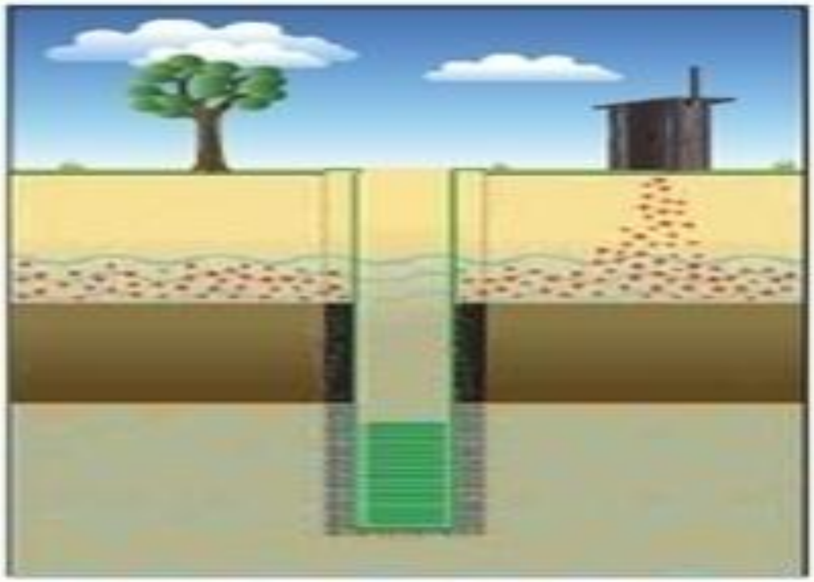


Figure 2.4. Bacterial migration in different aquifers with installed well and sanitary seal

Fecal Coli-form

The danger of Cali-form presence can rest on the health or sensitivity of the user. The concentrations of FC of groundwater do not contain any fecal coli-form; that means concentration of FC for its acceptable limits should be zero (0 cfu/100ml), (WHO, 2004).

Total Coli form

In drinking water, TC and FC should be absent (WHO, 2004). The presence of bacteria in water not only can cause objectionable odors but also may indicate a breakdown in the disinfection system (Corzatt, 1990). Total coliforms do not positively indicate contamination of fecal origin, (Amundson et al., 1988). Only fecal bacteria can positively indicate contamination by feces of humans or other warm-blooded animals, (Weigman & Kroehler, 1990).

The highest TC may be as a result of the refuse dump, human faeces scattered nearby the spring in the forest, dog excrement, decomposition of plant material by the action of microbial washed down into the soil and domestic animals that normally visit the site to drink and defecate around the water source. Bacterial growth commonly occurs on walls of pipes, valves, pipe fittings, aerators and surface of media in point-of-use products.

Generally, the highest TC is mainly effect of human activity, (Regunathan et al., 1983).
The diseases caused by water related microorganisms can be divided into four main categories:

i. **Water-borne diseases:** caused by water that has been contaminated by human, animal or chemical wastes. Examples include cholera, typhoid, meningitis, dysentery, hepatitis and diarrhea. Diarrhea is caused by a host of bacterial, viral and parasitic organisms most of which can be spread by contaminated water (WHO, 2006). Poor nutrition resulting from frequent attacks of diarrhea is the primary cause for stunted growth for millions of children in the developing world (Gadgil, 1998).
ii. **Water-related vector diseases:** These are diseases transmitted by vectors, such as mosquitoes that breed or live near water. Malaria causes over 1 million deaths a year alone (WHO, 2006). Stagnant and poorly managed waters provide the breeding grounds for malaria-carrying mosquitoes.
iii. **Water-based diseases:** These are caused by parasitic aquatic organisms referred to as helminthes and can be transmitted via skin penetration or contact.
iv. **Water-scarce diseases:** These diseases flourish in conditions where freshwater is scarce and sanitation is poor. Examples include trachoma and tuberculosis.

Testing the bacterial contaminants in water can be simplified by utilizing the presence of an indicator organism. An indicator organism may not necessarily pose a health risk but it can be easily isolated and enumerated, is present in large numbers, is more resistant to disinfection than pathogens, and does not multiply in water and distribution systems (Gadgil, 1998). Traditionally, total coli form bacteria have been used to indicate the presence of fecal contamination; however, this parameter has been found to exist and grow in soil and water environments and is therefore considered a poor parameter for measuring the presence of pathogens (Stevens et al., 2003).
Studies also show that due to their ability to grow in drinking water distribution systems and their unpredictable presence in water supplies during outbreaks of waterborne disease, the sanitary significance or quality of water is difficult to interpret in the presence of total coli forms (Stevens *et al*., 2003).

An exception is *Escherichia coli* (*E.coli*), a thermo tolerant coli form, the most numerous of the total coli form group found in animal or human feces, rarely grows in the environment and is considered the most specific indicator of fecal contamination in drinking-water (WHO, 2004). The presence of *E. coli* provides strong evidence of recent fecal contamination (WHO, 2004, Stevens *et al*., 2003).The risk of coli form presence can depend on the health or sensitivity of the consumer. The risks of *E. coli* presence, slightly greater than WHO Guideline's zero count per 100ml may be of only low or intermediate risk. According to IRC, 2002 as cited by Michael H., 2006 about risk classification for thermo tolerant coli forms or *E. coli* of rural water supplies.

Table 0.1 Water quality counts per 100ml and the associated risk

Counter per 100ml	Risk Category
0	In conformity with WHO guidelines
0-10	Low risk
11-100	Intermediate risk
101-1000	High risk
>1000	Very high risk

2.7. Safe Drinking Water

Safe drinking water is required for all usual domestic purposes, including drinking, food preparation and personal hygiene. Every effort should be made to achieve drinking water that is as safe as practicable (WHO, 2011). The nature and form of drinking water standards may vary among countries and regions. There is no single approach that is universally applicable. It is essential in the development and implementation of standards that the current or planned legislation relating to water, health and local government is taken into account and that the capacity of regulators in the country is assessed. Approaches that may work in one country or region will not necessarily transfer to other countries or regions. It is essential that each country review its needs and capacities in developing a regulatory framework (WHO, 2011). Based on the water quality standards stipulated by the WHO ranks were assigned for each parameter depending on the respective tested values, as given below.

Table 0.2. Drinking water quality standards of Ethiopia and WHO (from Ethiopian standard guidelines ES 261:2001; and WHO, 2011).

Drinking Water Quality Parameter	WHO standard (mg/L)	Ethiopian Standard (mg/L)
Nitrate	50	50
Arsenic	0.01	0.01
Fluoride	1.5	1.5
Magnesium	50	50
Chloride	250	250
Calcium	75	75
Sodium	200	200
Sulfate	250	250
TDS	1000	1000
PH	6.5-8.5	6.5-8.5
TDS	500	1,500
EC	250	NA
TC	0	0
FC	0	0
Turbidity	5	5

2.8. Perception of drinking water

In terms of drinking water quality, user perception is one of the most important things, sometimes exceeding actual quality of water especially when it concerns the quality of drinking water for the user communities (Sheat 1992, Doria 2010).

There are different factors that influence the perception of drinking water quality, including: Human sensory perceptions of taste, odor and color of water are related with mental factors and some extent taste, which is the more important because it may detect water contamination related to chemicals. People may perceive risks if they experience health problem caused by water.

2.8.1. Physical and aesthetic parameters

Consumer perception and acceptability of their drinking water quality depends on user sense of taste, odor and appearance (Sheat 1992; Doria 2010). That is why consumers have differing opinion about the aesthetic values of water quality.

Relying on their own senses may lead to avoidance of highly turbid or colored but otherwise safe waters in favor of more aesthetically acceptable but potentially unsafe water sources (WHO, 2004).

Taste and odor can originate from various natural chemical contaminants, biological sources, microbial activity, from corrosion or as a result of water treatment (e.g., chlorination) (WHO, 2004). Color, cloudiness, particulate matter and visible organisms can also contribute to unacceptability of water sources. These factors can vary for each community and are dependent on local conditions and characteristics.

In the present study, since the objective was to assess the effect of anthropogenic activities on the ground water quality, water quality parameters like pH, TDS, EC, Turbidity, Total hardness, Total alkalinity, potassium, Nitrate, Fluoride, Sodium, Chloride, Sulfate, Fical coliform, and Total coliform were to be used for assessing the effects.

2.9.Review of previous Literature

Study of Water quality parameter is very important in providing necessary data or information that can be used for health of society. Many investigators have studied on water quality at different parts of Ethiopia and other areas.

Josef (2015) studied evaluation of GWQ of Gimbi distric taking 12 samples and get the result of some physical, chemical and biological parameters such as temperature range 23.60 to 26.18 ^{0}C exceeds $15^{0}C$, pH range 4.71 to 6.20 fell below the range of 6.5 to 8.5). Turbidity(1.06 to 10.33 NTU),which indicates that higher levels of turbidity than the WHO recommended limit of 5 NTU, EC (38.67 to 233 μS/cm), which was less than the WHO recommended limit of 250 mg/l. Manganese ranging from 0 to 0.31mg/L and low concentration levels than WHO prescribed limit of 0.1 mg/l at all locations. The bacteriological analysis also revealed that all the water sources contained high Fecal and Total Coli-form counts ranging 17 to 396 and 284 to 4586 cfu/100 ml respectively. This implies that the Consumption of water contaminated from water sources may cause public health problems.

According to Asmellash (2014),hydro geochemical and water quality investigation on irrigation and drinking water supplies in Mekele, region, Ethiopia, findings of the study shows water resources in the study areas are evolved from Ca-HCO_3 water types to Ca-SO_4 through CaHCO_3-SO_4 and Ca- SO_4-HCO_3 water types. But, small numbers of observations with distinct sodium, chloride and nitrate signal were also identified possibility indicating contamination by urban and agricultural activities. The result of the study reveal that anthropogenic activities are the main effect on hydro geochemical process observed during hydro geochemical evolution of the water resources. By large study significant number of water resources observation don't meet WHO water quality standard for domestic uses including 38.5% for TS, 82.5% for TH and 19% for nitrate. More over 83% of the water resource data have corrosive character though 100% is not aggressive. Generally the water resources in the region are characterized with low salinity and low alkalinity controlled by geology, land use, water-rock interaction, and anthropogenic effects.

As studied by Aderaw T.(2014), Assessing ground water quality of Addis Ababa city by using Geographical Information System the major water quality parameters such as Total Dissolved Solids, Total hardness, Chloride, Nitrate, Sulphates, Magnesium and Calcium have been analyzed.

The spatial variation maps of these groundwater quality parameters shows that mostly in the central part of the city there is high concentration of nitrate, TDS, total hardness.

But from those parameters chloride, Magnesium, calcium and sulphate have low concentration below the world health Organization standard. From the WQI assessment the map showed that 78.18 % of the groundwater of the city were found to be in the excellent water class, 20.86% good, 0.9 % poor and the remaining 0.06 % was classified under very poor water class based on the computed WQI classification results.

CHAPTER THREE

1. MATERIALS AND METHODS

3.1. Description of Study area

3.1.1. General

Oromia special zone surrounding Finfine is the name given to a zone which was established in August 2008 as one of the nineteen zones of Oromia National Regional State. This Zone is located in the central part of Oromia National Regional State and the administrative center of the zone is located in Addis Ababa city. Burayu town is one of the nine municipal town administrations in Oromia Special Zone Surrounding Finfine where the research is conducted. Burayu, where population of the area highly increasing is located on the periphery of Addis Ababa, the capital city of Ethiopia almost 15 km on the west (Ambo-Wollagga) road.

Astronomically the town extends roughly from $9^{o}02' 21''$to $9^{o}02'30''$ North latitudes and $38^{o}03'30''$ to $38^{o}41'30''$ East longitudes with an elevation lying between 2626 and 2250 meters -above sea level. The mean annual rainfall is 1,188mm. The mean minimum and maximum annual temperature ranges between 16 and 23°C.

According to the administration official report, the population of the town in 2017 is estimated to be 300,000 in six kebeles. The the town is full of ups and downs topography and it covers about 7879 ha of land area. Majority of the land is classified as residential, industrial, and commercial, (Wubshet Hirphas, 2015). The name Burayu is reportedly derived from one of the indigenous trees of the region. The term “Burayu” is an Oromiffa word which means “Tiqure Inchet” (it literally means black wood) in Amharic. The forest, which also consists of other indigenous trees like “Tid”, “Woira”, “Kosso” etc., used to the home of a large variety of wild animals including Buffaloes, Lion, Giraffe, Tigers, etc. However, due to population increase and intensification of farming activities, significant deforestation occurred in the area that resulted in the migration of the wild animals (OUPI, 2006).In Burayu, sources of water include groundwater, river, spring water, Lake.

Groundwater is the main source of the area on which this study focuses.

During the study period sample is taken almost about 5km one from the other to know the difference of the water quality of the selected areas based on objective criteria.

Selection of the groundwater depends on human activities mainly at waste generation of the area and industrial activities. Hydrography of the selected ground water projects were related with topography of the area since altitude of the location can be factor for the groundwater quality.

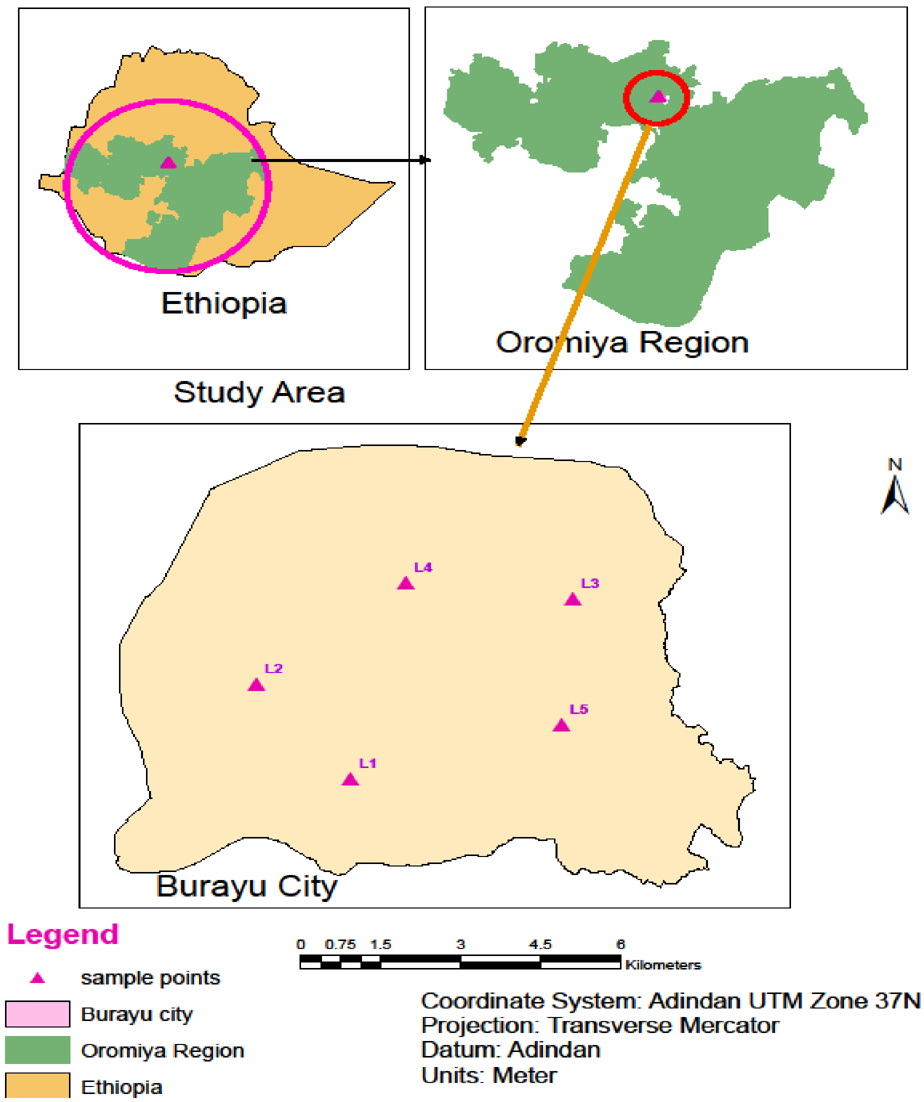


Figure. 3.1 Map of the study area

L1=BM_1, L_4=BM_4, L2=BM_2, L_5=BM_5 ,L3=BM_3 Where L=Sample point

3.1.2. Description of the GW wells of the study area

The big and hot issue in this world is utilization of water resources properly both domestic purpose and for any other development activities.

This issue is not an issue of only developed countries but also for non developed countries. The big percentage of water is occupied by surface water followed by GW. Burayyu GW project is under taken by Oromia National State Water, Mines and Energy Resource Bureau to Burayu town with **Al-Nile Business Group P.L.C** on January **2011** for both drilling and construction work of the well. Even if the the quantity of the groundwater wells are more than 14 the operating wells are eight in number. Currently five more wells are under construction.

Some wells where samples were collected are given below with some socio-economic activities. Sources of wastes can be point or non point source. Point sources are identifiable localized sources such as pollutants from industries and sewage. While nonpoint sources are those taken from point source by other factors such as run off and snow melt. In Burayu, almost all of the pollutant sources of GW wells are nonpoint sources.

Figure 3.2. Gafarsa Burayu area Borehole and surrounding pollutant sources

Figure 3.3. Burayu Katta area Borehole some pollutant sources

Figure 3.4. Gafarsa Guje area Borehole

Figure 3.4. Gafarsa Guje area Borehole

Sources of the ground water are protected spring, hand dug well and hand dag bore hole. The depth of the well ranges from 150m to 350m with different geological layer as listed in the table below.

Table 3.1. Geological layer of most Burayu wells per depth (for average of 5 wells).

Depth(m)		Litho logical Description
0	4	Clay soil
4	42	Scoracious basalt
42	46	Basalt intercalated with clay
46	54	Fractured and weathered basalt
54	80	Scoracious basalt
80	100	Massive basalt
100	148	Clay soil
148	160	Moderately and fractured basalt
160	168	Clay soil
168	174	Massive
174	222	Fractured basalt intar
222	246	Clay
246	258	Fractured basalt intercalated with clay
258	280	Clay
280	292	Massive
292	310	Fractured basalt

3.2. Materials

Some of the laboratory apparatus used in the analyses are those listed below. Evaporating dishes(used for separating solid particle), Analytical balance(to balance analytical samples), beaker(to measure samples), graduated cylinder, standard flasks, Funnel, Wash bottle, Forceps, Measuring jar, Burette with burette stand, Pipette with elongated tips, Pipette bulb, Dish tongs, Gooch crucibles, Filter, Vacuum pumps, Crucible tongs, Measuring cylinders , conical Flasks, Spectrophotometric tube, Drying oven, Desiccators, pH meter with a combination of pH electrode and temperature compensation probe, UV-Spectrophotometer, conductivity meter, Burettes and stand, autoclave, fume hook, Petri dish, filter unit, Incubator and photo cameras.

3.3. Method

3.3.1. Study period and design

The study was carried out in five kebeles namely: Gafhrsa Burayu, Gafarsa Nonno, Gafarsa Guje and Lakku Kule from the beginning of January to the end of June 2017. This research design is a study design that gives the relative proof for causation. Laboratory findings of the research were takes place in the laboratory because it aims at finding out the relationship existing between two factors under controlled conditions. Thus, the research strictly adopts the Scientific method in its investigation.

3.3.2. Study variables

The study variables were physical parameters (temperature, pH, electrical conductivity, total dissolved solid, turbidity and dissolved oxygen) and chemical parameters (total alkalinity, total hardness, calcium, magnesium, carbonate, bicarbonate, sodium, potassium, iron, manganese, chloride, sulfate, nitrate) and biological parameters(total and fecal coliform). These are independent variables while Suitability of ground water quality (given by WHO) is dependent variables.

3.3.3. Sampling Design

Groundwater samples were collected by purposive sampling technique from five different groundwater wells. For selection of groundwater sampling location, the criteria followed were those listed below.

The criteria includes : wells closer to polluting sources like garbage dumpsites, Improper waste disposal sites, Natural deposits minerals, municipal effluents, leakage of gasoil from fuel oil storage tank, road construction, Garages, municipal Abattoir. Water samples were collected from pumping wells after minimum of several minutes of pumping prior to sampling. This was done to remove groundwater stored in the well. Samples were drawn with a pre cleaned plastic polyethylene bottle. Prior to sampling, all the sampling containers were washed and rinsed thoroughly with the groundwater. Water quality parameters such as Ph and electrical conductivity (EC) will be analyzed onsite immediately.

The samples were filled up to the brim and were immediately sealed to avoid exposure to air and were labeled according to the location name systematically. The necessary precautions were adopted during sampling (Brown et al., 1974).

Table 3.2. GPS Reading of the selected sites in the study area

Sampling area	Name of the location	Water sources	GPS Reading(m)		
L_1	Industrial zone	Bore hole	460589.85	998930.76	2562
L_2	Gafarsa Nonno	Bore hole	459781.36	998549.6	2572
L_3	Gafarsa Guje	Bore hole	458006.29	1000647.6	2585
L_4	Gafarsa Burayu/xace	Bore hole	467035.34	1003412	2250
L_5	Burayu/Katta	Bore hole	4723560.5	1013533	2598

3.3.4. Sample analysis

Physical and chemical analyses of the water samples were analyzed in Oromia Water Works Design and Supervision Enterprise (OWWDSE) Laboratory. Bacteriological analyses of the water were made in Ethiopian Construction, Design and Supervision Works Corporation Research, Laboratory and Training Center.

For rest of the analysis, water samples were preserved and bought to the laboratory within short time and were determined as per standard methods (APHA-1995).

The chemical analysis such as Calcium, Magnesium, Iron and Manganese concentration were measured by Atomic Absorption Spectrophotometer. Chloride and bicarbonate were estimated by volumetric titration methods. Nitrate was estimated by spectrophotometer methods and sodium and potassium by flame photometry methods. All the results were compared with standard limits recommended by WHO (2004).

Interpretation of all water chemistry data were carried out using Microsoft excels (2007). The analyzed data was presented by using table, figure and piper diagram. Columns are one of the most useful ways of representing and comparing water quality.

CHAPER FOUR

1. RESULTS AND DISCUSSION

4.1. Physical Parameters

Table 4.1.Result of some physical parameters

S.N	Sample Location	EC (µS/cm)	PH	Turbidity (NTU)	TDS (mg/l)
L_1	Industrial zone	193.7	6.2	O.58	96.8
L_2	Gafarsa Nonno	215	6.5	0.6	110
L_3	Gafarsa Guje	240	7.1	0.6	90
L_4	Gafarsa Buayu/xace	345	7.8	1	89
L_5	Burayu Katta	352	8.3	0.71	176

4.1.1. pH

The pH of groundwater samples ranges from 6.2 to 8.3.The highest pH (8.3) was observed at location L_5 and the lowest (6.2) was observed at L_1.The limit of pH value for drinking water is specified as 6.5 to 8.5 (WHO, 2004). The result clearly shows that the groundwater in the study area is of two groups some of those found around industrial areas are slightly acidic in nature while those of waste disposal area are basic in nature. This may be due to the presence of some acidic chemicals released and organic acids which are derived from the anthropogenic activities, decay and subsequent leaching of plant materials as well as leachate flows from waste. This source affects the nature of the water not to have normal character. However, when water has a pH that is too low, it will lead to corrosion and pitting of pipes in plumbing in distribution systems. When we compare L_1 and L_5 with L_3 there is difference in pH. This is expected to be released from industrial activities and open dump waste disposed to the areas.

Because L_3 is reference well more free of anthropogenic activities. It was concluded that the pH value of groundwater samples of study area is suitable for drinking purpose except at L_1 where more industrial activity seen. The feature effect of the human activity creates fear at the area, since concentration of pollutant affecting water character increases with time unless waste treatment of the area under taken.

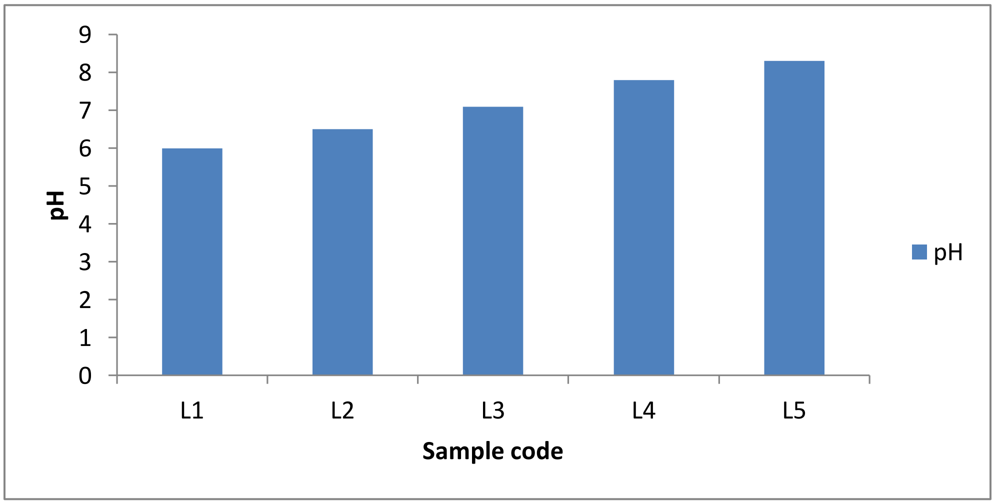


Figure 4.1. Variation of groundwater pH in study area

4.1.2. Electrical Conductivity

The electrical conductivity of groundwater samples ranges from 193.7 to 352 µS /cm. The highest EC (352 µS /cm) was observed at location L_5 and the lowest EC (193.7 µS /cm) was observed at L_1. The most desirable limit of EC in drinking water is prescribed as 250µs/cm (WHO, 2004). The conductivity of clean water is lower but as it moves down the earth it leaches and dissolves ions from the soil and also picks up organic from biota and detritus. Lower EC in the study area indicates the low enrichment of salts in the ground water. As observed from (Figure.4.2). Some of the water samples are suitable for drinking purpose because its conductivity does not exceed 250µS/cm. But some groundwater of L_4 and L_5 are above allowed standard. This means the EC value of the all study area does not fallen below the WHO standards; which shows the conductivity values recorded in the study area can pose Potential health risk for consumers.

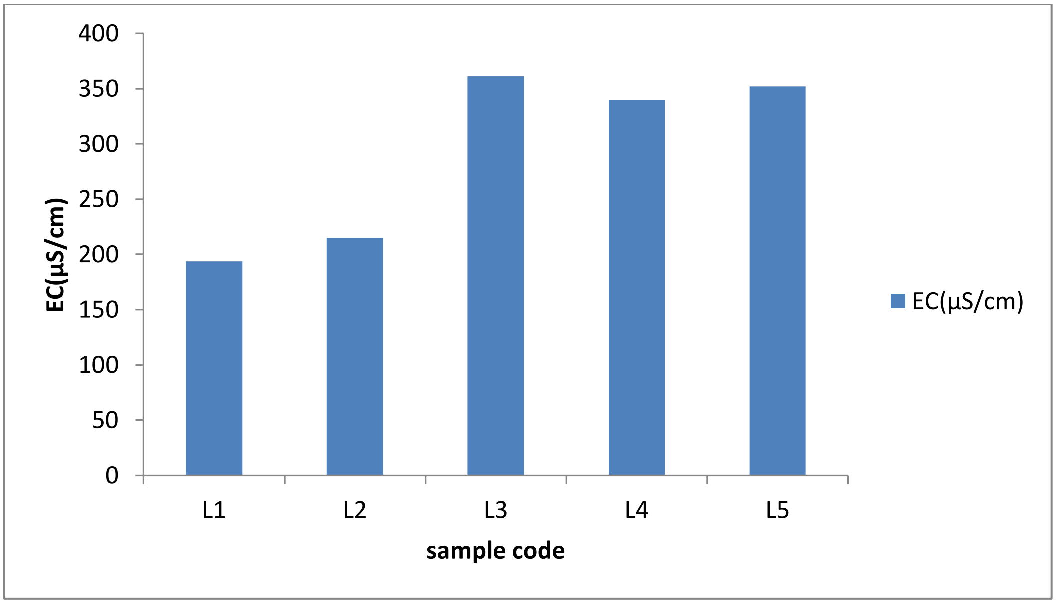


Figure 4.2. Graphical representation of Variation in EC at study area

4.1.3. Total Dissolved Solids

The total dissolved solid value varies between a minimum 89mg/l and a maximum of 176 mg/l. The highest TDS (176 mg/l) was recorded at location L_5 and the lowest (89 mg/l) was observed at L_4. This may be derived from natural sources which includes inorganic salts, principally calcium, magnesium, potassium, sodium, bicarbonate, chlorides, sulfates, and small amounts of organic matter that are dissolved in water. From the study observations of the areas the reference point, where there is low human activities contains low amount of TDS also originate from different activities such as industrial, commercial, agricultural and municipal wastes generated to land surface which then end up at water sources through sewage and urban run-off. Groundwater samples in study area contain less than 500 mg/l of dissolved solids; but it can cause health effect after certain years. It can be concluded that the TDS of groundwater samples of study area is below the WHO (500mg/l) and national standard, but variation of concentration of TDS among well shows that the effect of human activities on GW qualities. Therefore, as we see currently population growth increasing dramatically and it accelerate unsuitability of water sources there decreasing water quality.

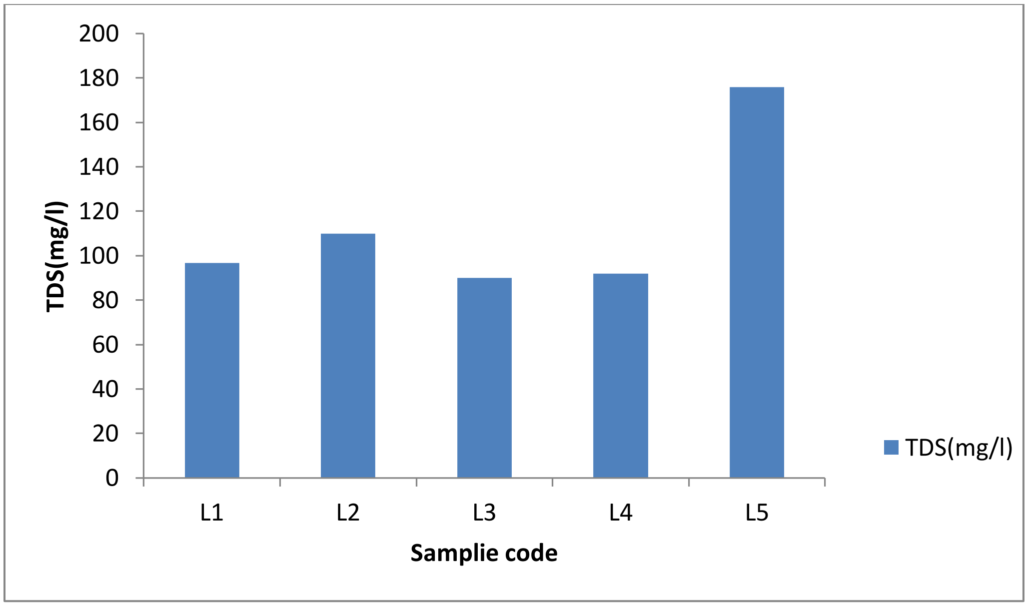


Figure: 4.3. Graphical representation of TDS at study area.

4.1.4. Turbidity

In present study the turbidity values of groundwater samples ranged from 0.58 at L_1 to 1 NTU at L_2. However, the prescribed limit of turbidity for drinking water is 5 NTU (WHO, 2004). The high turbidity of groundwater in the study area may be due to urban runoff, decaying plants and animals. Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. Turbidity of water affects other water quality parameters such as color is imparted by colloidal particles. It also promotes the microbial proliferation, thus affecting negatively the microbiological quality of water. It can be concluded that groundwater samples in study area were below the WHO standard which is suitable for drinking purpose.

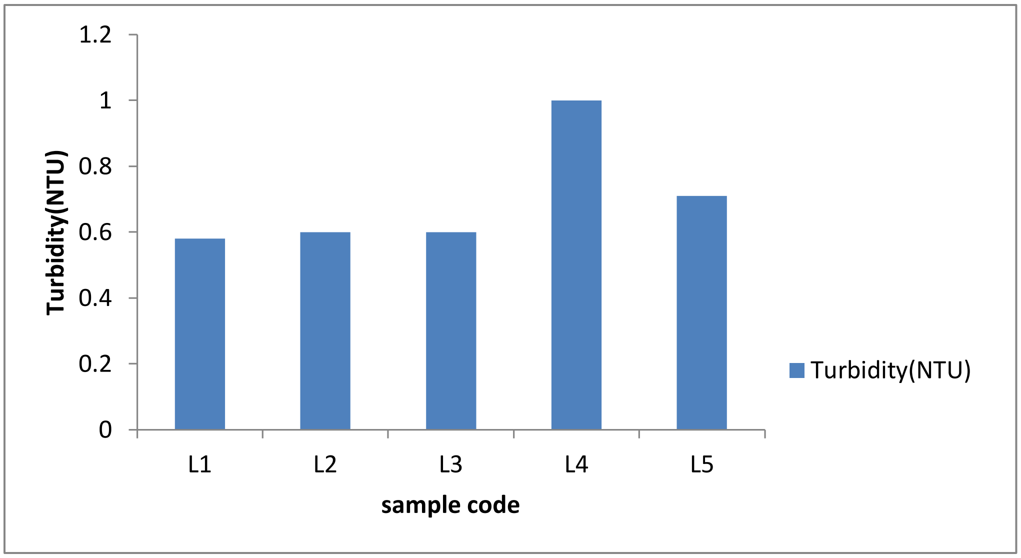


Figure: 4.3. Graphical representation of TDS at study area.

4.2. Chemical Parameters

Table 4.2. Results of Chemical Parameters

S. N	Sample Location	TH	TA	SO_4	HCO_3	Ca	**Na**	K	Mg	Fe	Cl
L_1	I/zone	21.9	110	0.68	110	6.5	6.9	5.1	1.38	0.02	13.5
L_2	G/nonno	24	90	0.73	90	6.7	7.7	5.45	1.75	0.05	12.5
L_3	G/Guje	27	120	0.48	120	7.4	5.49	1.34	2.07	0.1	10.5
L_4	B/Katta	19.9	150	1.92	150	5.3	23.2	2.35	1.63	0.03	16
L_5	G/B/xace	4.3	195	1.37	195	1.4	20	5.8	0.17	0.08	18.5

4.2.1. Total Hardness

A total hardness value of groundwater samples varies from 4.3 to 27 mg/l. According to the pot-ability of drinking Water set by WHO standard, the maximum permissible allowable limit should not be exceeded 500mg/l. The TH value of study area may be due to presence of calcium and magnesium.

Hardness does not have health effects but it can make the water unsuitable for different use. High range of TH in water may cause corrosion in pipes in the presence of certain heavy metals. The degree of hardness of groundwater supply the study area can be categorized as soft water, which is not harmful for consumers according to the WHO and Ethiopian standards 200mg/l and 500mg/l respectively. It can be concluded that the concentration of total hardness of groundwater samples in study area was suitable for drinking purpose. When observed an average, the nature of the geological site of wells is different.

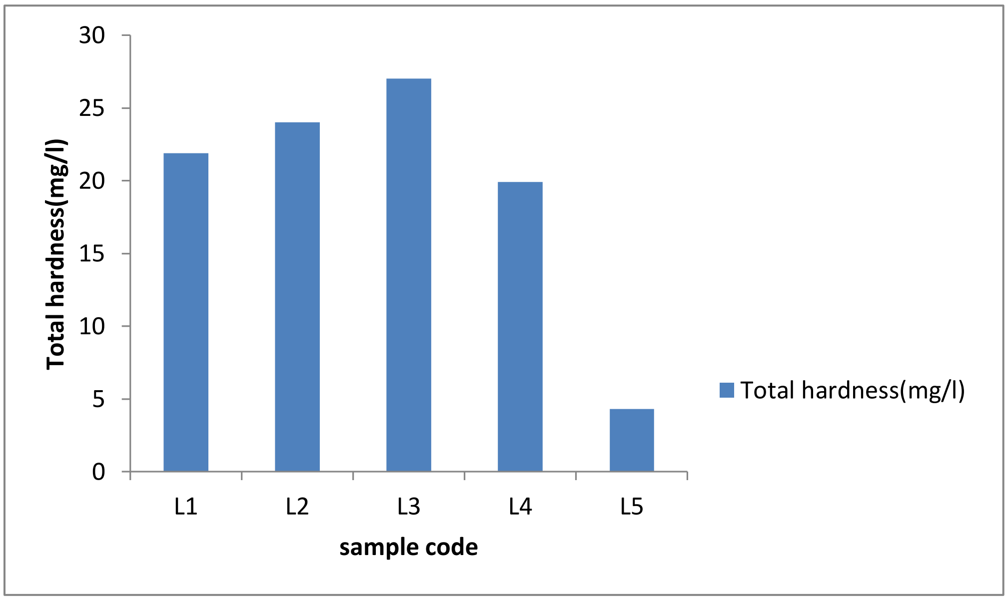


Figure 4.5.Variation of groundwater TH in study area

4.2.2. Total Alkalinity

TA=OH^- alkalinity+CO_3^-alkalinity+HCO^-_3alkalinity.But, the alkalinity of the $CO_3^-$and OH^- is zero from the result. Therefore, TA is equal with alkalinity of the HCO^-_3 at the study areas. The alkalinity measurements ranged from 90mg/l at L_1 to 195mg/l at L_5. According to the portability of drinking Water set by WHO standard, the maximum permissible allowable limit should not be exceeded 200mg/l as $CaCO_3$. These results show that at all points of sample taken the values of total alkalinity lay below the WHO maximum permissible limit. Thus, there is no significance harm effect on human health. However, excessive quantities may cause a number of problems.

Thus, these values were under the permissible limit of WHO standards and may not caused health related problems. It can be concluded that alkalinity of the groundwater in the study area was suitable for drinking purpose but, since the most of the GW at the study area show difference hardness in not more than five years. So, for the feature it is easy to forecast water quality decreasing dramatically due to increasing urbanization and industrial activities.

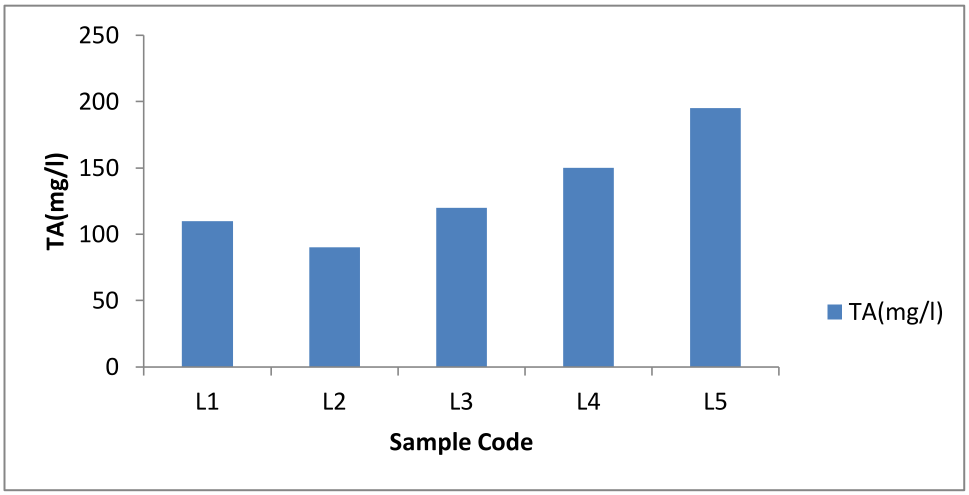
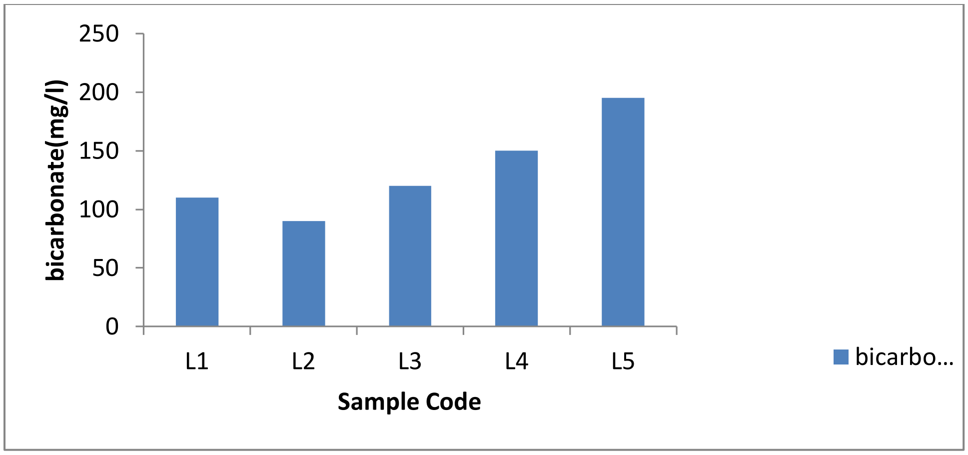


Figure .4. 6. Variation of groundwater TA in study area

4.2.3. Bicarbonate

The bicarbonate measurements of groundwater samples ranged from 90 mg/l at L_2 to195 mg/l at L_5 (Table 4.7.). The value of bicarbonates is not recommended by WHO or Ethiopian standard. However it is considered to be not more than 500 mg/l. The weathering of rocks adds bicarbonate content in water. Mostly bicarbonates are soluble in water i.e. bicarbonate of magnesium and calcium etc. Human activity is the other main causes of hardness of water. The concentration of bicarbonate in study area was below the standard.

It can be concluded that the concentration of bicarbonate of groundwater samples of study area was suitable for drinking purpose but, it is visible that the human activities varies the concentration of bicarbonate from place to place based on the density of the activities.



4.2.4. Chloride: In study area the chloride value ranges from 10.5mg/l at L_1 to 18.5 mg/l at L_5. According to WHO (2004) standards concentration of chloride should not exceed 250 mg/l.All the groundwater samples have lower concentration of chloride maximum permissible limit value set by WHO standard. Thus the water for all study area considered as fresh water because they were containing low levels of chloride.

Therefore it can be concluded that the concentration of chloride in groundwater samples was suitable for drinking purposes, even though the variation in concentration in the high human activity in the areas indicating its effect on GW quality.

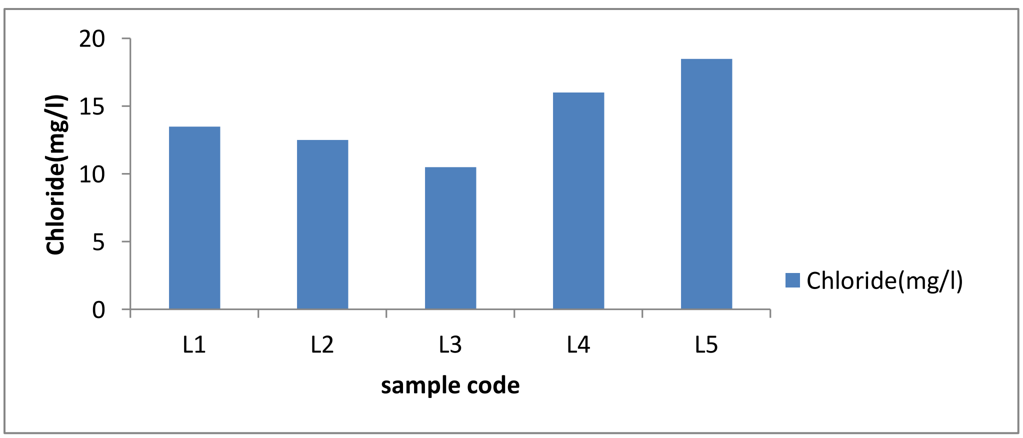


Figure: 4.8. Variation of groundwater chloride in study area

4.2.5. Nitrate (NO_3^-)

Nitrate in study area ranged from 0.16 at L_5 to 4.86 mg/l at L_3**.** The WHO allows maximum permissible limit of nitrate in drinking water is 10 mg/l.

But the concentration of nitrate in groundwater samples of study area was fallen below the WHO and national standard. The source of nitrate might be the agricultural fields which uses fertilizers. Nitrate one of the most important diseases causing parameters of water quality particularly blue baby syndrome in infants. It was concluded that the water in the study area did not have nitrate concentration that could lead to health problems. Therefore the results indicate that the concentration of nitrate in study area was suitable for drinking and irrigation purpose.

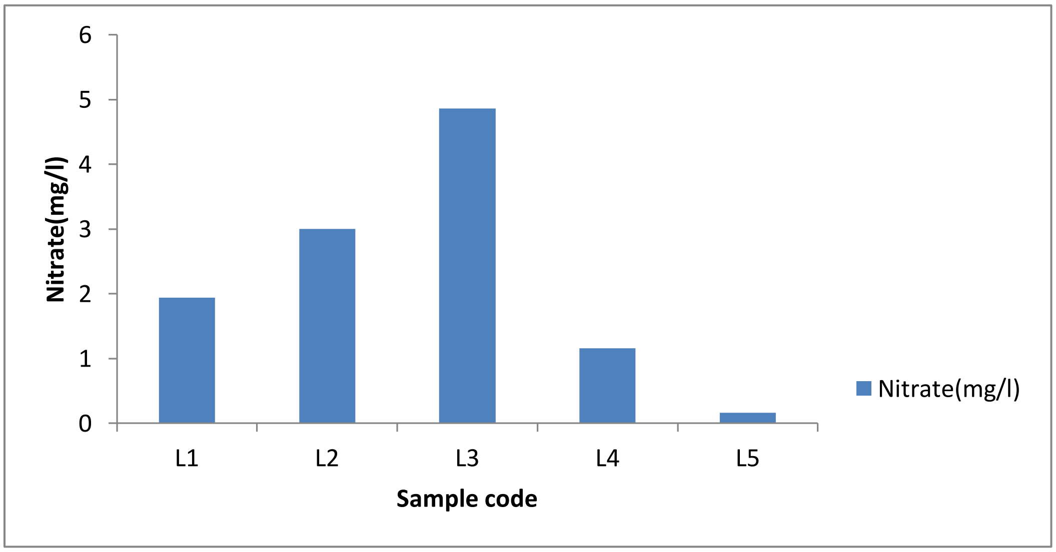


Figure 0.9.Variation of groundwater nitrate in study area

4.2.6. Sulfate (SO_4^{2-})

Sulfate in study area ranged from 0.48 to 1.92mg/l. The WHO has established 250 mg/l as the highest desirable limit of sulfate in drinking water. Sulfate mainly derived from the dissolution of salts of sulfuric acid and abundantly found in almost all water bodies. Accordingly, the laboratory results of study area at all points of sample location where the values were below the maximum permissible limit set by WHO standard. There is no significance effect on the health of the users. Therefore, the results clearly indicate that the concentration of sulfate in study area was suitable for drinking purpose.

But, the result shows variation of concentration of sulfate between high human activities and that of low human activities; which gradually affect water quality and in turn human health.

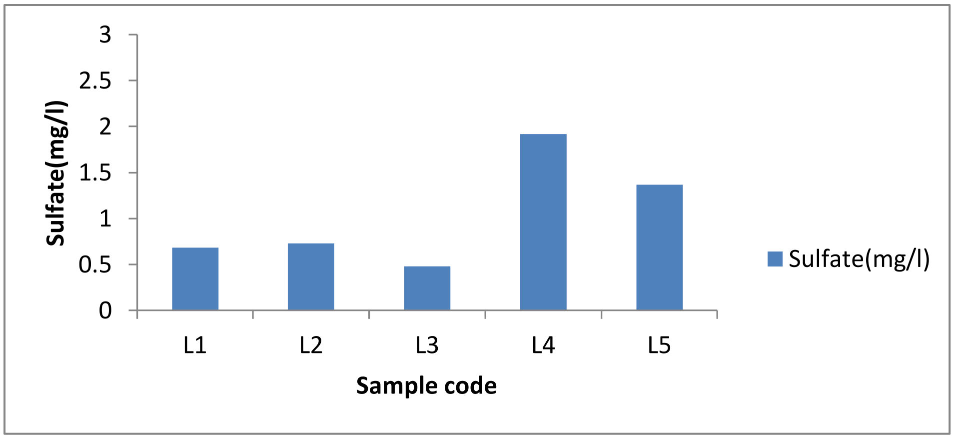
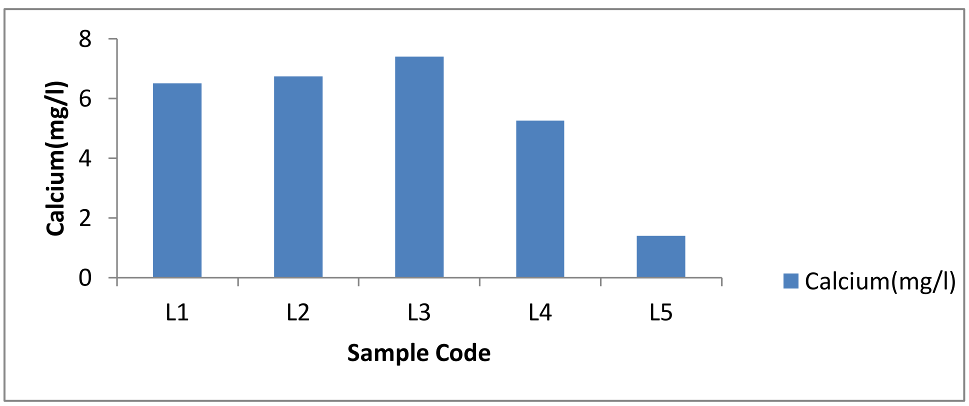


Figure: 4.10. Variation of groundwater sulfate in study area

4.2.7. Calcium

Calcium concentration of study area ranged from 1.4mg/l at L_5 to 7.4mg/l at L_3.

The desirable limit of calcium concentration for drinking water is specified as 200mg/l (WHO, 2004). The high deficiency of calcium in humans may cause rickets, poor blood clotting, bones fracture etc. The exceeding limit of calcium produced cardiovascular diseases (Magesh, et al., 2012). The result shows the values were below the maximum permissible limit set by WHO standard. This implies that the source of water is almost soft water and there is no any health effect and economic implication on the users.



4.2.8. Magnesium

Magnesium concentration of study area ranged from 0.17 mg/l L5 to 2.07mg/l at L3. According to WHO standards the permissible range of magnesium in water should be 150 mg/l. The quantity of magnesium is significantly low in study area.

Such a low concentration somewhat affects health of residents as it is essential for human body. Magnesium was found in less quantity such that the hardness of the water in some water points was related to calcium than magnesium. It can be concluded that the concentration of magnesium in groundwater samples of study area was suitable for drinking purposes.

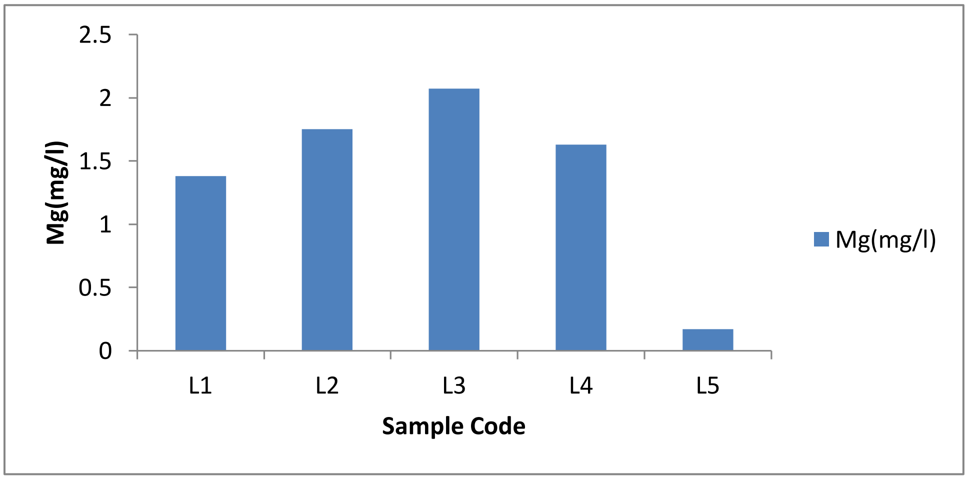


Figure: 4.11Variation of Magnesium in study area

4.2.9. Potassium

The concentration of K^+ in study area is varied from 1.34 at L_3 to 5.81 mg/l at L_5. According to WHO standards the permissible limit of potassium is 10 mg/1.These results were meet the WHO standards and may become preventive from diseases associated from potassium extreme deficiency. The laboratory result of potassium concentration at all groundwater sample points of the location of the study area were found below the maximum permissible limit value set by WHO as shown in Figure below.

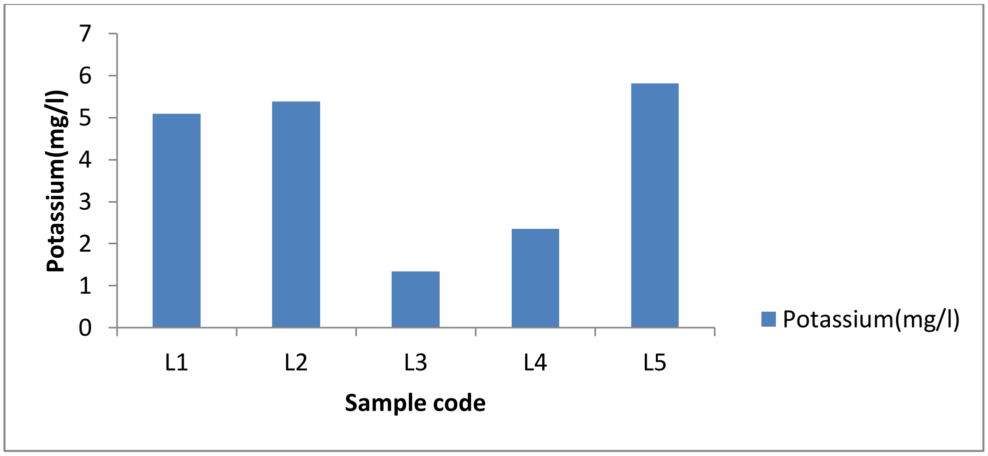


Figure 4.12.Variation of potassium in groundwater in study area

4.2.10. Iron

The concentration of Fe^{2+} is varied from 0.02 to 0.1 mg/l. In drinking water the desirable concentration set by WHO (2004) is 0.3 mg/l for iron. Rock and mineral dissolution are causes of high iron levels in groundwater. The variation of concentration of Iron in the area may be due to the result of the weathering of rocks and minerals and cast iron pipes during water distribution (Hem,1972). Long term consumption of drinking water with high concentration of iron may leads to liver diseases (Gyamfi et al. 2012). Nearly all the studied sites have acceptable levels of Fe^{2+}. It can be concluded that most of the concentration of iron in study area were suitable for drinking purpose.

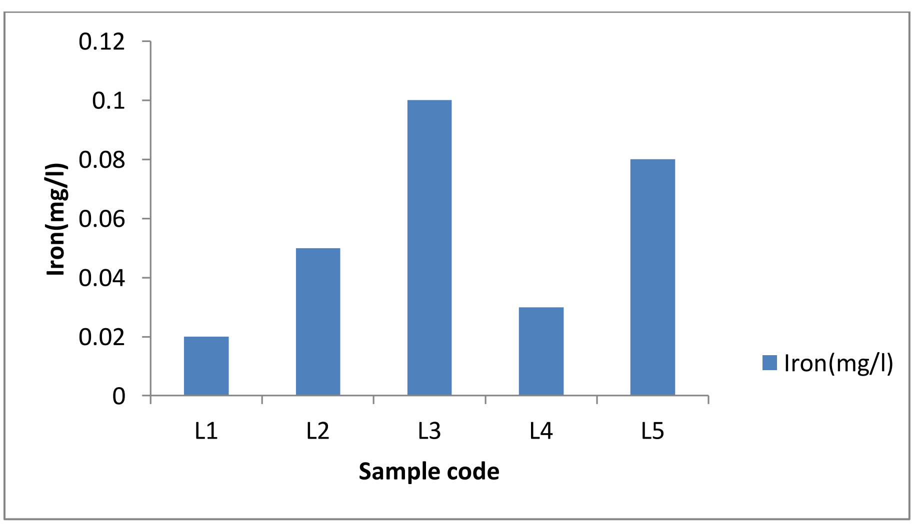


Figure: 4.13. Variation of iron in study area

4.3. Biological Parameters

Table.4.3. Results of Bacteriological Parameters

S.N.	Sample Location	Fical Coliform	Total Coliform
L_1	Industrial zone	40	400
L_2	Gafarsa Nonno	36	375
L_3	Gafarsa Guje	9	300
L_4	Burayu katta	10	394
L_5	Gafarsa Buayu/xache	35	305

4.3.1. Fecal Coli form (FC)

The results of analysis indicated that the values of fecal coliform (FC) ranged from 9 cfu/100ml at $L_3$to 40cfu/100ml at L_1. In drinking water, TC and FC should be absent (WHO, 2004). The danger of coliform presence can rest on the health or sensitivity of the user. The concentration of FC obtained from the groundwater samples exceeds the acceptable limits (0 cfu/100ml) in all the investigated wells, bore holes and protected spring. From the result, it may be concluded that drinking water samples collected from all the water sources are not safe for human consumption. From the result L_3 and L_4 shows low fecal colform. From the study at L_3 effect of human activity which release pathogen is low while the well at L4 is about 310 meter depth; this is expected to prevent more pathogens/bacteria from the ground water due to most of the may be die before.(Arjen vander Wal,2010)

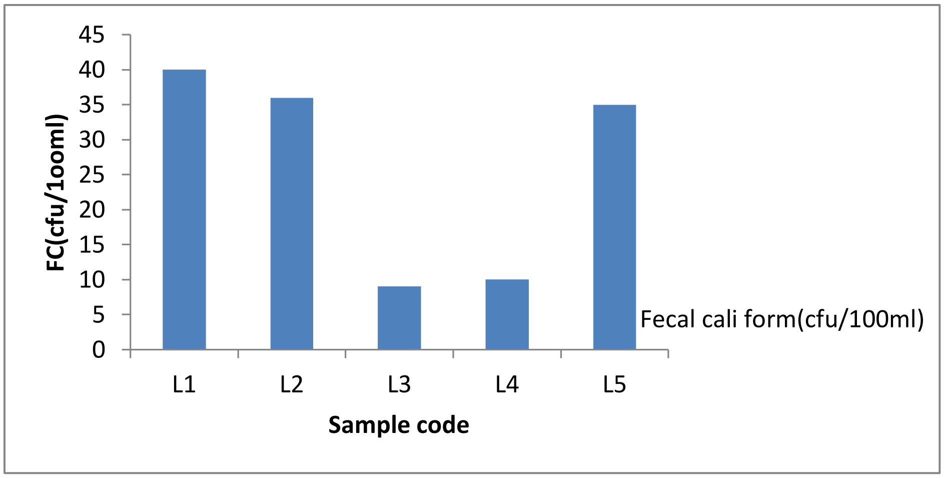


Figure: 4.14. Variation of Fical coliform in study area

4.3.2. Total Coli form (TC)

The results of analysis indicated that the values of TC ranged from 300 cfu/100ml to 400 cfu/100ml at L_3, L_4 respectively (Table 4.17.). In drinking water, TC and FC should be absent (WHO, 2004). The presence of bacteria in water not only can cause objectionable odors but also may indicate a breakdown in the disinfection system (Corzatt, 1990). Total coliforms do not positively indicate contamination of fecal origin (Amundson et al., 1988). Only fecal bacteria can positively indicate contamination by feces of humans or other warm-blooded animals (Weigman & Kroehler, 1990).

The highest TC may be as a result of the refuse dump, human faeces scattered nearby the spring in the forest, dog excrement, decomposition of plant material by the action of microbial washed down into the soil and domestic animals that normally visit the site to drink and defecate around the water source. Bacterial growth commonly occurs on walls of pipes, valves, pipe fittings, aerators and surface of media in point-of-use products. There is shown from the result that L_3 and L_5 are different from the other wells due to variance factors. This includes geological layer, flow direction, catchment ,and human activity. At L_3 including other factor low human activity is the main reason. Generally, the highest TC is mainly effect of human activity, (Regunathan et al., 1983).

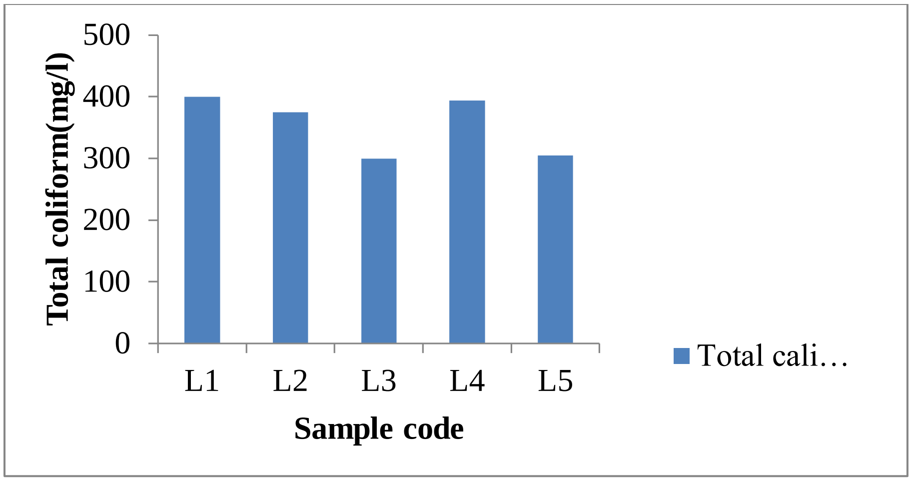


Figure: 4.15. Variation of Total coliform in study area

Summary of water quality parameter achieved at study areas by the range and mean values given below is the average result during study season(winter).

Table: 0.4. Minimum, maximum and mean physic-chemical and biological parameters of groundwater in study area.

Parameters	Range	Mean
EC(µS/cm)	193.7-361	292.34
Ph	5.00-8.30	6.56
Turbidity(NTU)	0.58-1.00	0.698
TDS(mg/l)	89-110	112.36
TH(mg/l as $CaCO_3$)	4.3-27	19.42
TA(mg/l as $CaCO_3$)	90-195	133
HCO_3^-(mg/l as $CaCO_3$)	90-195	133
NO_3^-(mg/l)	0.16-4.8	2.224
Cl^-(mg/l)	10.5-18.5	14.2
$SO^{2-}{}_4$(mg/l)	0.48-1.92	1.036
FC (cfu/100 ml)	9-40	26
TC (cfu/100 ml)	400-300	346.8

Table.0.5. Minimum, maximum and mean of metal analysis of groundwater in study area.

Parameters	Range	Average	WHO Standards	Ethiopian Standards
Mg^{2+}	0.17-2.07	1.396	50	150
Ca^{2+}	1.4-7.40	0.056	75	200
Na^{+}	5.49-23.20	12.694	200	358
K^{+}	1.34-5.81	8.03	10	50
Mn^{2+}	0.00	0.00	0.1	0.5
Fe^{2+}	0.02-0.10	0.20	0.3	0.4

Table: 0.6. Study area physical and biological parameters comparisons with standards of (WHO, 2004) and Ethiopian Standards.

S.N.	Sample Location	EC (µS/cm)	PH	Turbidity (NTU)	TDS (mg/l)	FC(cfu/100ml)	TC(cfu/100ml)
L_1	Industrial zone	193.7	6.2	O.58	96.8	40	400
L_2	Gafarsa Nonno	215	6.5	0.6	110	36	375
L_3	Gafarsa Guje	240	7.1	0.6	90	9	300
L_4	Gafarsa Buayu/xace	345	7.8	1	89	10	394
L_5	Burayu Katta	352	8.3	0.71	176	35	305
Minimum		193.7	5.00	0.58	89	9	305
Maximum		352	8.30	1.00	110	40	400
Mean		292.34	6.56	0.69	112.36	26	346.8
WHO (2004)		250	6.5-8.5	5	500	0	0
Ethiopian Standards		NA	6.5-8.5	5	1500	0	0

Figure 4.16.Sampling areas

Figure. 4.17. Libratory analysis of GW Samples

CHAPTER FIVE

1. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The groundwater is the main water source in the study area. The study period was at dry season; it implies summer study will show high effect of human activities due to runoff and infiltration. The main physic-chemical parameters considered for investigation include turbidity, pH, electrical conductivity, total dissolved solids, total hardness, total alkalinity, carbonate, bicarbonate, calcium, potassium, sodium, magnesium, iron, chloride, nitrate and sulfate. Bacteriological tests such as fecal coli forms and total coli form were analyzed. The laboratory results have shown that except for total coli form, fecal coli form and pH the remaining all parameters were found within the permissible limit of WHO standard and Ethiopian recommended values concerning the safety and acceptability level.

But the study shows GW around industrial activities and waste disposal site, the water quality parameters are low when compare with GW at low human activity which is taken as reference. That means this small variation will attack human health through time. For example TC, FC and pH of the nature of the water can be changed after long period of time. The study of the physic-chemical parameters in the present investigation indicates that the groundwater quality is almost within the standard limits at all locations. For the case of total hardness and TDS of almost all samples, the groundwater from study area is found to be safe and suitable for drinking purposes.

Generally, concerning the physic-chemical parameters, the water seems to be not safe and there is significant effect on the health of the users. The results of bacteriological analyses and some physical and chemical analysis have shown that all of the sample points are at very high risk.

Therefore, it is concluded that this risk expected to be the effect of human activity because of the low human activity area is more acceptable compared to other areas.

5.2. Recommendations

By recognizing the reality of ground water quality distribution from the study, the following recommendations should be considered.

- ❖ Continuous monitoring of groundwater table along with quality study will minimize the chances of further deterioration.
- ❖ Awareness and training programs should be conducted for the NGO’s and the local people for the sustainable use and management of groundwater of the study area.
- ❖ The result shows that the existing groundwater supply of study area is of three categories acidic, basic and neutral. Therefore, Burayu Water Supply Authority should adjust pH ranges by injecting Soda Ash (Sodium Carbonate) solution to neutralize acids and neutralize bases by hydrogen and sulfur compounds of acidic media.
- ❖ The result shows that the concentration of fluoride at L_5 of the groundwater supply of study area is above WHO standard. Therefore, Burayu Water Supply Authority should consider the problem and report to Authorized Organ.
- ❖ The result shows that a high degree of faecal and total coliform contamination which are poor and unsuitable for human consumption. Thus, it would be wise that all water sources should be treated with chlorination or boiling before being used
- ❖ The hand dug wells are open, it has to be sealed or closed in order to protect from any water born diseases.
- ❖ Before constructing wells, geological suitability of the area, acceptance within the community and the capability of operating and maintaining the system has to be assessed.
- ❖ Site selection should be precede well construction to decrease pollution of groundwater and used for identifying impermeability of soil.
- ❖ Summer study should be conducted during the rainy season since the pollution is likely to increase from runoff and infiltration.

REFERENCES

Aderaw T. (2014), Assessing ground water quality of Addis Ababa city by using Geographical Information System

Addis Ababa central Stastical Agency,2010.

Anonymous, 2008. Assessment of surface water for drinking quality. Directorate of Land Reclamation Punjab, Irrigation and Power Department, Canal Bank, Mughalpura, Lahore, Pakistan.

American Public Health Association, 1995. Standard Methods for the Examination of Water and Waste, 14th Edition Washington D. C. Pp. 76-265

Appelo, C.A.J. and D. Postma (2005). Geochemistry: Groundwater and pollution. 2nd Ed. Balkema, Rotterdam.

Asmellash (2014), Hydro geochemical and water quality investigation on irrigation and drinking water supplies

AYERES R. S and WESTCOT D.W, 1994. Water quality for agriculture. FAO Irrigation and Drainage Paper.

AYERES R.S (1976). Water Quality for Agriculture. Food and Agricultural Organization of the United Nations, Rome. Irrigation and Drainage paper, No. 29.

Balakrishnan, P., Saleem, A., and N. D. Mallikarjun , 2011. Groundwater quality mapping using geographic information system (GIS): A case study of Gulbarga City, Karnataka, India. African Journal of Environmental Science and Technology, Vol. 5, No. 12, Pp: 1069-1084.

Babu, K.N., Padmalal, D., Maya, K., Sreeja, R. and Arun, P.R, 2007. Quality of Surface and Ground Water Around Tile and Brick Clay Mines in the Chalakudy River Basin, Southwestern India. Jour. Geol. Soc. India, Vol.69, Pp: 279-284.

Barcelona, M. J., Gibb, J. P., Helfrich, J.A., et al, 1985. Practical guide for groundwater sampling (E. a. N. Resources, Trans.) (Pp. 103): Illinois State Water Survey.

Bartran, J. and R. Balance, 1996. Water Quality Monitoring: A Practical Guide to the Design and Implementation of Fresh Water Quality Studies and Monitoring Programmes. E and F.N. Spoon: London, UK.

Bear J., 1979. Hydraulics of Groundwater. McGraw-Hill International Book, New York

CAWST, 2013. Introduction to Drinking water Quality Testing.

Central ground water board ministry of water resources government of India, 2010. Ground water quality in shallow aquifer of India.

Chilton. J, 1996.Water Quality Assessments : A Guide to Use of Biota, Sediments and Water in Environmental Monitoring **.** UNESCO/WHO/UNEP, Second Edition.

Crossgrove, J. and W. Zheng, 2004. Manganese toxicity upon overexposure. NMR Biomedicine, Vol. 17, Pp: 544–553.

Doneen, L.D., 1964. Water quality for agriculture. Department of Irrigation, University of Calfornia, Davis, 48.

Doria M. D. F, 2010. Factors influencing public perception of drinking water quality. water policy Vol.12, Pp: 1-19.

Eaton, F.M., 1950. Significance of carbonate in irrigation waters. Soil Science, Vol. 69, Pp: 123-133.

Elton, N.W., W.J. Elton and J.P. Narzareno, 1963. Pathology of acute salt poisoning in infants. American Journal of clinical pathology, Vol. 39, Pp: 252-264.

Emsley, J., 2003. Manganese. Nature's building blocks: an A–Z guide to the elements, USA: Oxford University, Pp: 249-253.

Fetter, CW.,1994. Applied Hydrogeology**,** Third Eddition. Prentice Hall, New Jersy.

Freeze, R. A., Cherry, J. A., 1979. Groundwater: Prentice Hall Inc, New Jersey

Gadgil A., 1998. Drinking water in developing countries. Lawrence Berkeley National laboratory,environmental energy technologies division, 1 Cyclotron Road, California, s.1.

Gupta, D. P., Sunita and J. P. Saharan, 2009. Physiochemical Analysis of Ground Water of Selected Area of Kaithal City (Haryana) India, Researcher, 1(2), Pp: 1-5.

HARTER T., 2003. Groundwater Quality and Pollution. FWQP Reference Sheet 11.2, University of California.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 2254, 263 p.

Hounslow, A. W., 1995. Water quality data; analysis and interpretation.Unite States of America: LEWIS.

Iliopoulos, V., Stamatis, G.,and Stournaras, G.,2011. Marine and human activity effects on the groundwater quality of Thriassio Plain, Attica, Greece. [Advances in the Research of Aquatic Environment]. Environmental Earth Sciences, Pp: 409-419.

Jensen, P.K., J.H.J. Ensink, G. Jayasinghe, W. Van der Hoek, S. Cairncross and A. Dalsgaard, 2003. Effect of Chlorination of Drinking-water on Water Quality and Childhood Diarrhoea in a Village in Pakistan. 21, Pp:26-31.

Joshi, D.M., A. Kumar and N. Agrawal, 2009. Assessment of the irrigation water quality of River Ganga in Haridwar District. Rasayan journal of chemistry, 2(2), Pp: 285-292.

Karthikeyan.N, Saranya.A,and Sashikkumar M.C., 2013. Spatial analysis of Ground water quality for virudhunagar district, Tamil Nadu Using GIS.

Kebede T. and Tadesse H.M., (1990). Engineering Geological Map of Addis Ababa, EIGS (unpublished report)

Khodapanah, L., W.N.A. Sulaiman and N. Khodapanah, 2009. Groundwater Quality Assessment for different Purposes in Eshtehard District, Tehran, Iran. European Journal of Scientific Research, 36(4), Pp: 543-553.

Madrid, Y., and Zayas, Z. P., 2007. Water sampling: Traditional methods and new approaches in water sampling strategy.

Mazor, E.,1991. Applied Chemical and Isotopic Groundwater Hydrology. USA, Canada and Latin America: HALSTED PRESS.

Michael H., 2006. Drinking water quality assessment and treatment in east Timor a case study: Tangkae, the University of East Timor.

Mirabbasi, R., S.M. Mazloumzadeh and M.B. Rahnama, 2008. Evaluation of irrigation water quality using fuzzy logic. Research Journal of Environmental Sciences, Vol. 2, No.5, Pp: 340-352.

Muhammad, M., Samira, S., Fayal, A., & Farrukh, J., 2013. Assessment of Drinking Water Quality and its impact on Residents Health in Bahawalpur City. *International Jornal of Humanities and Social Science*, Vol.3, No.15.

Nickson, R. T., McArthur, J. M., Shrestha, B., Kyaw- Nyint, T.O., Lowry, D., Arsenic and other drinking water quality issues, Muzaffargarh District. Pakistan Applied Geochemistry, Pp: 55–68, 2005.

Patil, P. R., Badgujar, S. R., and Warke A. M. 2001. Oriental J Chem. 17 (2), Pp: 283.

Patil, V.T., and Patil, P.R., 2010. Physicochemical Analysis of Selected Groundwater Samples of Amalner Town in Jalgaon District, Maharashtra, India. E-Journal of Chemistry. 7(1), Pp: 111-116.

Raghunath, M., 1987. Groundwater, 2nd Ed., Wiley Eastern Ltd., New Delhi, India.

Ramesh.K and Elango,L., 2011. Groundwater quality and its suitability for domestic and agricultural use in Tondiar river basin, Tamil Nadu, India, Environ Monit Assess DOI 10.1007/s10661-011-2231-3.

Reddy, K.S.S.N. and T.A. Reddy, 2011. Qualitative characterization of groundwater resources for irrigation: a case study from Srikakulam area, Andhra pradesh, India. International Journal of Engineering Science and Technology, 3(6), Pp: 4879-4887.

Sadashivaiah, C., C.R. Ramakrishnaiah and G. Ranganna, 2008. Hydrochemical Analysis and Evaluation of Groundwater Quality in Tumkur Taluk, Karnataka State, India. Int. J. Environ. Res. Public Health, 5(3): 158-164

Simeonov, V., Stratis, J. A., Samara, C., Zachariadis, G., Voutsa, D., Anthemidis, A., Sofoniou, M. and Kouimtzis, T.H., 2003. Assessment of the surface water quality in Northern Greece. Water Research, Vol.37, Pp: 4119–4124.

Shahnawaz, M., and Singh K. M. 2009. Ground Water Quality of Piro and Jagdishpur Blocks of Bhojpur District: A Middle Gangatic Plain. International Journal of Pharmaceutical

Quality Assurance. 1(1):9-12.Sheat A., 1992. Public perception of drinking water quality. Should we care? Paper presented at the New Zealand Water Supply and Disposal Association Annual Conference. Cited in Syme & Williams (1993). Slovic, P. (2000). The Perception of Risk. Earthscan, London.

Sreedevi, P.D. Groundwater quality of Pageru river basin, Cuddepah district Andhra Pradesh. J. Goel. Soc. India, Vol.64 (5), 2004: pp.619– 636.

Stevens M., Ashbolt N. and Cunliffe D. (2003). Recommendation to change the use of coli form as microbial indicators of drinking water quality. Australia Government National Health and Medical Research Council.

Subba Rao, N., 2006. Seasonal variation of groundwater quality in a part of Guntur District, Andhra Pradesh, India. Journal Environ Geol 49: 413–429.

Trivedy, R.K. and P.K. Geol, 1984. Chemical and biological methods for water pollution studies. Karad: Environ Publications.

TWDB (Texas Water Development Board), 2002, People and groundwater.Water for Texas.Texas Water Development Board, Document no.GP-7-1, Austin, Texas, 156 pp. <http://www.esi.utexas.edu> (accessed on 29 November 2008).

UNEP , 2003. Groundwater and its susceptibility to degradation: A global assessment of the problem and options for management.

UNICEF, 2008. UNICEF hand book on water quality. United Nations Children's Fund

(UNICEF), New York.

Van Koppen, B., Moriarty, P., Boelee, 2006. Multiple-Use water Services to Advance the Millennium Development Goals. Research Report 98, IWMI, Colombo Sri Lanka.

WHO, 2011. Guidelines for Drinking-Water Quality, Fourth Edition. WHO,Geneva,

Switzerland.

Wilcox L.V., The quality of water for irrigation use vol. 40. US Department of Agriculture Technology Bulletin 962, Washington DC, 1948.

Wubshet Hirpasa, 2015. Investigation on the Engineering Processes of Soil found in Burayu Town.

ZHANG H., 1990. Classification of Irrigation Water Quality. Oklahoma State University Soil, Water and Forage Analytical Laboratory. Oklahoma Cooperative Extension, Factsheet PSS-2401-4.

ANNEXES

Annex 1.)

1A. Temperature, Electrical Conductivity, P^H, TDS and Dissolved oxygen determination

Temperature, conductivity, pH, TDS and DO of the water samples were determined with a multi parameter probe. The meter was calibrated prior to use with 0.001 N and 0.10 N standard potassium chloride solutions (according to the manufacturer's specifications) and buffer standards of pH 4, 7 and 9.2 at room temperature. The analysis involved dipping the probe of the meter directly into 100 ml water sample measured in a beaker, then taking the reading as displayed on the screen of the equipment. After each measurement, the probe was rinsed in distilled water and the display mode adjusted to the standardization value for measurement of the next parameter.

1B.) Turbidity Determination:

Turbidity was determined using the Nephelometric method (APHA, 1998) with turbidity meter in which the sample was shaken vigorously and transferred into a sample cell to at least two-thirds full. The sample cell was placed in the turbid meter and the appropriate range on the turbid meter was selected. The stable turbidity reading was then recorded.

1C.) Chloride Determination:

For the determination of Chloride, Mohr's argentometeric titration method was used.

One ml potassium chromate was added in 20 ml sample in a 250 ml conical flask and the solution turns yellow in color. The solution was titrated with 0.0141N $AgNO_3$ till the first brick red appears. This was the end point and noted down the volume of $AgNO_3$ added (V_s).

Blank titration :

- 1ml potassium chromate was added in 20 ml distilled water in a 250 ml conical flask and the solution turns yellow in color. The solution was titrated with 0.0141N $AgNO_3$ till the first brick red appears. This was the end point and noted down the volume of $AgNO_3$ added for distilled water (V_b).

Calculation :

$$\text{Chloride (mg/l)} = \frac{(Vs-Vb) \text{ x Nx1000 x35.45}}{S} \quad \ldots\ldots (3.1)$$

Where; V_s = volume of $AgNO_3$ for sample

V_b = volume of $AgNO_3$ for blank

S = volume of sample (ml)

1D. Total Hardness Determination:

A 20 ml sample was measured into a 250 ml conical flask. To this was added 5 drops of buffer solution and was then followed by the addition of 4-5 drops of erichome black-T was mixed. The mixture was titrated with 0.02 N EDTA solutions until the wine red color of the solution changed to blue (end point) and noted down the burette reading.

Calculation: Total hardness (mg/L) = $\frac{\text{Tx N x 50 x 1000}}{V}$ ………………………………….. (3.2)

Where; T = volume of EDTA

N = Normality

V = volume of sample

1E. Total Alkalinity Determination

A 50 ml of sample was pipette into a conical flask and 4-6 drops of phenolphthalein indicator was added in the solution and finally 3 drops of bromocresol was mixed with it respectively. In the samples, carbonates were absent as there was no color change appeared after addition of phenolphthalein indicator. To the same flask, 4 drops of methyl orange was added and titrated with 0.02N H_2SO_4 continued until the color changed from yellow to brick red which was the end point of bicarbonate and jot down the value (V_2).

Calculation:

Total alkalinity (mg / L) = $\frac{\text{Volume of sulphuric acid (V2)x N x 50 x 1000}}{\text{Volume of sample taken}}$ …………....…..…. (3.3)

HCO_3^- as mg $CaCO_3$ /L = $\frac{T-(5*10^{(PH-10)})}{1+0.94*10^{(PH-10)}}$ ……………………………..……… (3.4)

CO_3^{2-} as mg $CaCO_3$ /L $=0.94*HCO_3^-*10^{(PH-10)}$ ……………………………...... (3.5)

Where: T = total alkalinity as mg $CaCO_3$/l

Determination of Bicarbonate and Carbonate (Standard Analytical Procedures for Water Analysis, May 1999).

Alkalinity result	Bicarbonate, (mg $CaCO_3$/L)	Carbonate, (mg $CaCO_3$/L)
P = 0	T	0
P < ½T	T-2P	2P
P = ½T	0	2P
P > ½T	0	2(T-P)
P = T	0	0

Where; P = Phenolphthalein alkalinity

T = Total alkalinity

1F. Sulfate Determination

The water sample was checked with qualitative test whether the concentration of the sulfate exists or not before going to measure by UV-Spectrophotometer.

Qualitative test:

Two ml of the 37% HCl and 5ml of 10% $BaCl_2$ was added to 7ml water sample respectively. The sample was heated on flame to identify the existence of sulfate concentration in the water sample until white precipitation appeared. Finally the end result was white precipitation appeared, and then analysis indicate that sulfate concentration in the sample.

1G. Determination of Calcium ($Ca^{2+)}$ and Magnesium (Mg^{2+})

50 ml of water sample was diluted to 50 ml such that the calcium content was 5 - 10 mg. Samples which contain alkalinity greater than 300 mg/L was neutralized with acid and boiled for 1 minute and cooled before titration. 2 ml NaOH solution was produced a pH of 12 to 13 and the titration was immediately started after addition of the alkali and then 0.1 - 0.2 indicators was added.

Finally, titrated with EDTA solution, with continuous mixing, till the color was changed from pink to purple. The end point was checked by adding 1 to 2 drops excess titrant to make certain that no further color change occurs.

Calculation:

$$\text{Ca (mg / L)} = \frac{\text{Ax B x 400.8}}{\text{V}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.6)}$$

$$\text{Calcium hardness as } CaCO_3 \text{ (mg / L)} = \frac{\text{Ax B x 1000}}{\text{V}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.7)}$$

Where; A = ml titrant for sample

$$B = \frac{\text{mL of standard calcium solution taken for titration}}{\text{mL EDTA titrant}} \quad \ldots\ldots\ldots\ldots\ldots \text{(3.8)}$$

Mg (mg/L) = (Total Hardness as mg CaCO3/L - Calcium Hardness as mg CaCO3/L) x 0.243

1H. Determination of Sodium (Na^{+}) and Potassium (K^{+})

Sodium:

A blank and Sodium calibration standards was prepared in the ranges of 0-100, 0-10, or 0-1 mg Na/L. The instrument was set zero with standard containing no sodium and measured emission at

589nm and calibration curve was also prepared. The sodium concentration of the sample was determined from the curve.

Calculation:

Mg Na/L = mg Na/L from the calibration curve × Dilution ………………………….…….. (3.9)

Where: Dilution = $\frac{\text{ml sample+ml distilled water}}{\text{ml sample}}$ …………………………………….......... (3.10)

Potassium

A blank and Potassium calibration standards was prepared in the ranges of 0-100, 0-10, or 0-1 mg K/L. The instrument was set zero with standard containing no potassium and measured emission at 766 nm and calibration curve was also prepared. The Potassium concentration of the sample was determined from the curve.

Calculation:

Mg K/l = mg K/l from the calibration curve × Dilution……………………......… (3.11)

Where; Dilution = $\frac{\text{ml sample+ml distilled water}}{\text{ml sample}}$ …………………………….…… (3.12)

1I. Analysis of Iron and Manganese:

The concentrations in mg/L of two metals were determined in the samples namely, Fe and Mn with the Atomic Absorption Spectrophotometer(Perkin Elmer Analyst 400). The flame used for the analysis was air-acetylene mixture. A 100ml stock solution of two elements solution was obtained from the laboratory. Standard solutions ranging from 0.2 to 5.0mg/l were prepared for calibration curves of those metals. A blank analysis was performed with distilled water treated to the sample treatment. The following concentrations of metal solutions were prepared to determine the baseline absorbance value at Fe: 5.5 mg/l and Mn: 10 mg/l. The metal concentrations were determined one after the other using their respective hollow cathode lamps (HCL) and calibration curves. Air-acetylene wave flame was used for the analysis. The respective wavelengths employed for the metal determinations were Fe at 248.7 nm and Mn at 525 nm.

1J. Microbiological analysis of water samples:

Fecal coliform and total coliform bacteria were determined using the membrane-filter technique (APHA, 1992). One hundred milliliters of each sample were aseptically filtered through sterile 0.45μm-pore size membrane filters (Whatman) and the filters transferred onto agar nutrient (MacFaddin, 1985) with rosolic acid in glass Petri dishes for Coliform. petri dish was closed and labeled at the top of the lid with code number of the water sample and incubated at 37^0c for 24 hr. upon completion of the incubation period typical blue colored for fecal coliform and both red and blue colony for total coliform bacteria.

Annex 2

A) Results of the physical analysis of groundwater sample for the study areas.

Parameters	Result of the sample areas				
	L_1	L_2	L_3	L_4	L_5
PH	6.2	6.5	7.1	7.8	8.3
EC	193.7	215	240	345	352
TDS	96.8	110	90	89	176
Turbidity	0.58	0.6	0.6	1	0.71

Annex 3

A) Results of the chemical analysis of groundwater sample for the study area

Parameters8	Result of Sample areas				
	L_1	L2	L_3	L_4	L_5
Cl^-	13.5	12.5	10.5	16	18.5
SO_4^{-2}	0.6	0.73	0.48	1.92	1.32
TH	21.9	24	27	19.9	4.3
TA	110	90	120	150	195
NO_3^-	1.94	3	4.86	1.16	0.16
HCO_3^-	110	90	120	150	195

Annex 4

A) Results of the metal analysis of groundwater sample for the study area

Parameters	Results of the study areas				
	L_1	L_2	L_3	L_4	L_5
Ca^{+2}	6.5	6.74	7.4	5.26	1.4
Na^{+1}	6.93	7.74	5.49	23.2	20.11
K^{+1}	5.09	5.38	1.34	2.45	5.81
Mg^{+2}	1.38	1.75	2.07	1.63	0.17
Fe^{+2}	0.02	0.05	0.1	0.03	0.08

Annex 5

A) Results of Bacteriological quality of the groundwater samples for the study area

Parameters	Result of study areas				
	L_1	L_2	L_3	L_4	L_5
Fical coliform(cfu/100ml)	40	36	9	10	35
Total coliform(cfu/100ml)	400	375	300	394	305

Annex 6) photos during sampling time

Annex 7) Libratory photos

Annex. 8

A.) Map of the study area